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TWENTY-THIRD ANNUAL REPORT

OF THE

Mass. STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

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1891–1892.

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Secretary.

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Engineer.

F. P. STEARNS, C.E.

CONTENTS.

GENERAL REPORT.

The following report comprises the general work of the State Board of Health for the year ending Sept. 30, 1891, together with certain papers on special topics relating to public health.

The following are the general and special subjects embraced in the report: —

Report to the Legislature on Water Supply and Sewerage, including the Advice of the Board given under the Provisions of Chapter 375 of the Acts of 1888.

Reports upon Food and Drug Inspection.

Report upon Arsenic in Wall-papers and Fabrics.

Summary of Weekly Mortality Reports.

Paper upon the Geographical Distribution of Certain Diseases in Massachusetts.

Health of Towns.

The following members comprised the Board in 1891: —

Henry P. Walcott, *Chairman*.

Frank W. Draper,	Julius H. Appleton,
Hiram F. Mills,	Joseph W. Hastings,
Elijah U. Jones,	John M. Raymond.

The term of office of Julius H. Appleton expired in May, 1891, and Morris Schaff of Pittsfield was appointed a member of the Board.

At the annual meeting, held in June, 1891, the following officers were chosen: —

Chairman, ...	Henry P. Walcott.
Secretary, ...	Samuel W. Abbott.

The following officers of the Board were also chosen, under the provisions of chapter 375 of the Acts of 1888, and chapter 263 of the Acts of 1882: —

Under the Provisions of the Food and Drug Acts.

Analyst,	CHARLES P. WORCESTER.

Under the Provisions of the Acts to Protect the Purity of Inland Waters.

Chief Engineer,	FREDERIC P. STEARNS.
Consulting Engineer,	JOSEPH P. DAVIS.
Assistant Engineer,	X. H. GOODNOUGH.
Chemist,	THOS. M. DROWN.
Biologist,	W. T. SEDGWICK.
Chemist in Charge of Experiment Station,	ALLEN HAZEN.
Biologist at Experiment Station,	GEORGE W. FULLER.

INFECTIOUS DISEASES.

With a few exceptions, there were no serious and wide-spread epidemics in the State during the year ending Sept. 30, 1891. The unusual prevalence of typhoid fever in the cities of the lower Merrimac valley during November, December and January, 1890 and 1891, was made the subject of a special paper in the annual report of 1890.

Influenza, which prevailed with unusual severity in the winter of 1889 and 1890, was made the subject of a special report in the annual report of 1889. It reappeared with much diminished intensity in the following winter, but again returned with nearly if not quite as great intensity in the winter of 1891 and 1892. (See page 746, and diagram.)

Small-pox.

During the year 1891 small-pox has produced but little disturbance in Massachusetts. The State has been comparatively free from this disease for a period of nearly ten years. The whole number of deaths from this cause for the ten years ending with 1891 was 91, or an average of 9.1 per year. If 1882 be omitted, the annual average of the succeeding nine years was but 5 deaths per year. The following record embraces the details of such cases as were reported to the State Board of Health in 1891: —

Record of Cases reported to the Board in 1891, under the Provisions of Chapter 138 of the Acts of 1883.

Number.	Place of Occurrence.	Date of Report.	Nationality of Patient.	Age.	Sex.	Deaths.	Occupation.	Previously Vaccinated.	Number of Scars.
1	Spencer, . .	Jan. 17,	United States,	30	F.	-	House-wife, .	No.	0
2*	Holyoke, . .	April 18,	Irish, . .	19	F.	-	Paper-mill operative.	Yes.	1
3*	Lenox, . .	July —,	Fr. Canadian,	3	-	1	Father a shoemaker.	No.	0
4*	Pittsfield, .	July 17,	Fr. Canadian,	4	F.	-	Father a shoemaker.	No.	0
5	Lenox, . .	July —,	- -	-	M.	-	- -	?	-

* No. 2 was employed as a rag-cutter in paper-mill. Vaccinated in infancy. Nos. 3 and 4 were the children of a shoemaker who moved from Lenox to Pittsfield after the illness of No. 3.

A case of suspected small-pox was reported from Greenfield, April 29, and was removed to the pest-house. On the further development of the eruption, it proved to be measles.

A case reported from Cohasset, an adult, proved upon examination to be chicken-pox.

The following brief account is given of the cases which occurred at Pittsfield and Lenox. A child of a French Canadian family living in Lenox, aged one and a half years, was taken ill with an eruptive disease in June, 1891, and died June 30, the certificate which was given by the attending physician stating that it was a death from "chicken-pox and dentition." The events which followed, however, would seem to confirm a diagnosis of small-pox. The family moved to Pittsfield, and another child, aged three and a half years, was taken ill early in July, and on the 17th was seen by the secretary of the State Board, who at once pronounced it a case of small-pox. Meantime, another person in Lenox, an adult, who had been exposed to the first case as early as June 19, was taken ill with milder symptoms (varioloid), but not until July 11. Both the latter cases, one in Lenox and the other in Pittsfield, were isolated; careful precautions as to vaccination and disinfection were taken, and no other cases ensued.

Cases of Small-pox reported from Other States.

The following cases were reported from other States and provinces by the secretaries of the State and provincial boards of health, in compliance with the resolutions adopted

at Toronto in 1886 for the mutual notification of certain infectious diseases: —

Pennsylvania. — January 21, one case at Scranton; January 24, one at Erie; February 9, six cases at Johnsonburg and Pittsburg; February 20, two cases at Ridgeway; April 22, three at Philadelphia; November 16 and 23, two cases at Point Pleasant.

New York. — January 27, February 16, seven cases at Jamestown.

Wisconsin. — January 31, one at Prairie du Chien; April, ten cases at same place; April 21, May 6, two cases at Wright's Ferry.

Illinois. — April 2, two at Sparta; April 9, one at Chicago.

North Carolina. — April 5, two cases at Lexington.

Ohio. — January 23, one case at Urbana; May 18, one at Cleveland; November 29, one at Cincinnati and one at Glendale.

Connecticut. — April 11, one at Waterbury, said to have originated in Massachusetts; March 30, one at Greenwich.

Florida. — April 27, one at Jacksonville.

Tennessee. — May 18, one at Knoxville; June 9, seven at Knoxville; October 5, one at Obion; November 26, one at Memphis.

Iowa. — May 26, one at Council Bluffs.

Minnesota. — June 13, four cases at St. Paul; August 13, four more at St. Paul.

Michigan. — August 15, one at Sheboygan; September 21, one at St. Joseph's.

Province of Quebec. — March 25, one case at Sheffington; June 1, immigrants at Grosse Isle (quarantine); June 9, one case at Montreal; September 28 and October 6, eight cases at Carleton; October 10, seventeen cases at Macneeder. These appear to have been followed by a general epidemic, in which many cases and deaths occurred.

While the number of cases occurring in the State in 1891 was much less than those of the preceding year, the number reported throughout the country at large was considerably greater, although no serious epidemic appears to have prevailed except in the Province of Quebec, where one hundred and fifty cases and thirty-one deaths occurred between the middle of September and the close of the year.

With the possibility of many small outbreaks occurring in different parts of the country, and also in view of the abundant facilities of communication by railway travel, it is incumbent upon all our local health authorities to see that all the possible protection that vaccination affords should be extended to the people of their respective municipalities.

Typhoid Fever.

In consequence of the intimate connection of this disease with sewage-polluted water supplies, the Board has made it the subject of observation and experiment, and will report upon the results of observations in a later report. Special attention has been paid to the investigation of the conditions under which the disease has prevailed in those cities and towns which had an unusually high death rate from this cause.

The following table, published also in the report of 1890, presents the numbers of deaths from typhoid fever in the cities of Massachusetts for the twenty years 1871–90, together with the average annual death rate per 10,000 in each city from this cause. This table contains the same data for the added year 1890, which does not materially change the figures of the former period.

Deaths from Typhoid Fever in Cities of Massachusetts, 1871-1890.

	FIVE YEARS.	TWO YEARS.															
	1871-1875.	1876-1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	Total Twenty Years.	Average Annual Death Rate from Typhoid Fever per 10,000.
Boston,	1,145	318	106	120	151	212	223	167	202	148	142	180	174	176	146	3,667	5.11
Worcester,	176	67	20	13	31	21	28	18	20	19	19	30	25	21	14	512	4.24
Lowell,	221	46	27	22	22	54	50	49	41	49	50	90	62	69	125	977	8.45
Fall River,	176	68	26	23	35	32	51	33	26	32	30	45	46	48	40	711	7.04
Cambridge,	124	31	8	6	10	21	18	22	26	16	21	22	31	24	18	398	3.69
Lynn,	118	21	13	12	26	25	28	22	18	16	13	12	14	6	11	355	4.42
Lawrence,	190	42	30	23	27	49	31	28	19	17	23	47	48	55	60	689	9.23
Springfield,	214	44	18	8	16	27	22	28	18	22	12	17	26	19	14	505	7.30
New Bedford,	99	30	9	9	2	12	12	8	23	7	25	6	11	21	8	282	4.76
Somerville,	69	15	6	4	8	6	8	13	8	10	3	12	17	8	9	196	3.72
Holyoke,	157	31	7	19	20	30	58	21	23	18	17	17	21	23	27	489	11.09
Salem,	87	20	8	11	22	19	13	15	6	13	16	12	11	8	12	273	5.00
Chelsea,	86	15	10	2	9	9	5	5	10	8	4	6	6	11	8	194	4.23
Haverhill,	46	17	8	9	6	6	13	9	41	13	16	17	6	9	11	197	5.16
Brockton,	43	4	3	1	6	17	8	9	4	3	9	8	13	9	7	144	4.48
Taunton,	65	12	8	5	9	16	19	7	8	9	17	24	7	9	1	216	4.93
Newton,	20	10	6	5	4	6	5	1	11	8	6	8	12	13	5	120	3.33
Malden,	25	14	4	6	7	5	6	4	2	4	8	8	3	8	6	110	3.95
Fitchburg,	32	5	3	3	6	4	2	2	5	5	6	6	9	7	3	98	3.34
Gloucester,	51	15	11	3	5	7	7	10	7	7	7	4	9	2	3	148	3.78
Waltham,	13	1	2	1	4	5	3	3	6	3	5	5	2	1	4	58	2.26
Pittsfield,	56	15	1	4	9	7	10	5	10	2	8	10	9	5	8	159	5.80
Quincy,	19	11	3	1	6	2	8	3	8	6	1	12	12	6	6	104	4.64
Northampton,	46	6	6	3	4	8	2	7	10	2	6	3	6	5	2	116	4.73
Chicopee,	63	15	5	7	8	11	3	15	10	9	4	10	11	6	12	189	8.37
Newburyport,	29	11	3	10	7	7	6	2	3	4	1	3	2	5	6	99	3.65
Marlborough,	27	7	5	4	4	4	4	4	4	4	9	6	5	7	5	99	4.78
Woburn,	26	6	-	3	1	1	7	2	2	2	4	2	7	7	4	74	3.41
Totals,	3,423	892	356	337	465	632	650	512	541	456	482	622	605	588	575	11,179	5.37*

* Average, 28 cities.

The following affords an illustration of probable infection through the domestic water supply: —

Great Barrington. — The Board was requested to investigate certain cases of typhoid fever which occurred in Great Barrington in the fall of 1891. In August, 1891, a case occurred in the family of Mr. Hirsch, living near the village, in which one death occurred. It appeared that a drain leading from the kitchen sink past the well used by the family had been broken, allowing the discharge from the sink to soak into the soil near the well, with the probability of polluting the water. Other cases not fatal were said to have followed in the same family. The Board of Health requested the family to discontinue the use of the water of this well, and they complied, and soon moved out of the house. The sink drain was repaired very soon afterward, and while it was being repaired a boy from a neighboring family came and played about the drain; whether he drank of the water of the well could not be learned. This lad was taken ill with typhoid fever September 7, and died October 18. His illness was followed by five other cases in the same family, the disease having a continuous run in this family of three months. The persons attacked were the mother, four sons and a daughter aged six. Of these six, four died. In this house there was no drainage whatever. The kitchen sink had no outlet, and all sink water, as well as some of the excreta of the sick, were thrown out upon the ground about the well. The privy vault was situated across the yard, at a distance of about seventy-five to one hundred feet from the house, and a cow stable was somewhat nearer.

The water supply of this household was obtained from two sources, — from a cistern which was supplied from the roof, and from a well situated just outside the kitchen door. Both were provided with chain pumps. The well was mainly used for drinking water.

An analysis of the water of this well was made by the State Board, with the following result: —

Analysis of Sample of Water from Well in Great Barrington.

[Parts per 100,000.]

Sample collected Jan. 2, 1892.

Turbidity,	Very slight.	Total residue,	86.9
Sediment,	Slight.	Free ammonia,	.0
Color,	0.02	Albuminoid ammonia,	.006
Odor: —		Chlorine,	8.77
Cold, None.		Nitrates,	7.00
Hot, None.		Hardness,	45.72

The chlorine in this analysis should be compared with the normal chlorine of the waters of this region, which is about .10 per 100,000.

This analysis shows that the water was very much polluted at the time the sample was taken.

The origin of the first case of typhoid which occurred in August is unknown, but it appears probable that the cases in the second family originated in the visit of the little boy to the first house. He was the first to be taken ill, and the other cases followed, probably through infection of the drinking water of the well.

Diphtheria.

Several local epidemics of this disease were investigated by the Board during the year, the circumstances and conditions of which differed but little from those which have been detailed in former reports of the Board.

Hydrophobia.

During the year 1891 hydrophobia has gradually abated, until at the close of the year cases were reported very rarely. The number of deaths during the past decade has been as follows: —

1881,	3	1887,	0
1882,	0	1888,	2
1883,	0	1889,	14
1884,	0	1890,	17
1885,	0	1891,	9
1886,	0		

The following case is so fully confirmed and the account so carefully detailed by Dr. G. C. Pierce of Ashland as to be worthy of special notice : —

On July 14, three young children of Mr. C. Adams of Ashland were bitten by a dog supposed to be suffering from rabies. On the following day they were admitted to the Pasteur Institute in New York, under the charge of Dr. Gibier. On July 30, sixteen days after admission and treatment, they were discharged, and went home to Ashland, after having been pronounced to be out of danger from hydrophobia. On August 6, a week later, the boy, five years old, was taken ill with symptoms of hydrophobia, and died three days later, several physicians agreeing in the diagnosis of hydrophobia.

The circumstances of the infection were as follows: At 5 A.M., July 14, a shepherd dog ran madly through the streets of South Framingham, where he sprang upon a man and bit him in several places. A little daughter of Mr. Adams, aged seven, had started from home to pick berries. The dog rushed upon her, and inflicted twenty-one wounds with his teeth. He then attacked an older sister, aged eleven, and bit her hand. Next he attacked the little boy, and inflicted nineteen wounds upon him, and was then killed. The wounds were cauterized by a surgeon very soon afterward, and on the following day the children were sent to New York, in company with Mr. Dill of South Framingham, for treatment at the Pasteur Institute.

After returning home, the boy appeared well till Thursday afternoon, August 6. He was first attacked with nausea and vomiting. On the following day he had signs of fever. His face became alternately flushed and pale. On Saturday morning the temperature was 100° and the pulse slightly above normal. Pupil of left eye slightly dilated; constant twitching of angles of mouth; spasmodic action of muscles of forearms. Tongue slightly coated. No headache. By Saturday afternoon he was delirious, and refused food of all kinds. Difficulty in swallowing water. Eyes at times bright and glistening, and occasionally dull. Sunday morning he was worse. All symptoms increased in intensity. Temperature, 102½°; pulse, 130. An eruption appeared on chest and left cheek. Occasionally talked rationally; restless. Skin hyperæsthetic. A breath of air caused distress. He became emaciated for thirty-six hours

before death. The difficulty in swallowing increased throughout Sunday. He was continually delirious from 9 P.M. to his death, at 11.15 P.M.

It is stated that this is the first case of death following a course of treatment at the Institute of Dr. Gibier.

The Relation of Schools to Infectious Diseases.

There is no department of the management and control of infectious diseases which is of more importance than that which relates to school children. In the larger cities and towns the organization of boards of health has been so far perfected that the outbreak of infectious disease among children of school age does not create apprehension. Adequate measures are usually adopted for its suppression. But in the smaller towns, and especially in those which are habitually neglectful in sanitary matters, and refuse year after year to elect boards to have charge of the sanitary administration of the community, questions relative to the prevention of the spread of infectious diseases are of frequent occurrence, and give rise to very much trouble, in consequence of the inadequate means employed for their suppression. Conflicts of authority occasionally occur between boards of health, or selectmen acting as such, and school committees, as to the proper management of the public schools during the prevalence of epidemics of the diseases of children. The question often arises whether it shall be necessary to close a school in consequence of the prevalence of some infectious disease among the scholars.

The Local Government Board of England has recently issued a circular upon this subject, which contains so many excellent suggestions that we print it herewith in full. Many points are embraced within the suggestions of this circular which apply equally well to the conditions which are of constant occurrence in our own State.

Memorandum of the Circumstances under which the Closing of Public Elementary Schools or the Exclusion therefrom of Particular Children may be required in order to prevent the Spread of Disease.

1. It is attempted in these notes to bring together the information in the possession of the Local Government Board, derived from the reports of the Board's own inspectors and of medical officers of

health, respecting school closure and exclusion from school as precautions against infection. It is sought to indicate the best means of preventing the spread of disease by school children among their fellows while avoiding any unnecessary interruption of the work of education.

2. In the Code of Regulations approved by the Lords of the Committee of Council on Education, the following article prescribes, as one of the general conditions required to be fulfilled by a public elementary school in order to obtain an annual Parliamentary grant, that "The managers must at once comply with any notice of the sanitary authority of the district in which the school is situated, requiring them for a specified time, with a view to preventing the spread of disease, either to close the school or to exclude any scholars from attendance, but after complying they may appeal to the department, if they consider the notice to be unreasonable."

3. The diseases for the prevention of which school closure or the exclusion of particular children will be required are principally those which spread by infection directly from person to person, such as scarlet-fever, measles, diphtheria, whooping-cough, small-pox, rōtheln, — the order in which the several diseases are here given being about that of the relative frequency with which their occurrence gives rise to these questions at schools. More rarely, the same questions arise in connection with enteric fever, and diarrhœal diseases which spread, not so much by direct infection from person to person, as indirectly through the agency of local conditions, such as infected school privies.

4. It will be seen that the article quoted above confers upon sanitary authorities an alternative power with respect to public elementary schools.

(*a*) To cause particular scholars to be for a specified time excluded from attendance, or

(*b*) To require the school to be closed for a specified time.

5. (*A*) First, as to exclusion from school of particular scholars. Here it will be convenient to consider the circumstances under which the requirements of the public health will be satisfied by the less severe measure of the exclusion from school of particular children.

(*a*) It may be laid down as a universal principle that all children suffering from any dangerous infectious disorder (*i.e.*, of a nature dangerous to some of the persons attacked by it, however mild in other cases) should be excluded from school until there is reason to believe that they have ceased to be in an infectious condition.

(*b*) Furthermore, as it is rarely possible to provide effectual separation of the sick from the healthy within the homes of children of the class attending public elementary schools, it must commonly be necessary that all children of an infected household should be ex-

cluded from school; first, because otherwise such children might attend school while suffering from the disease in a latent form or at an unrecognized stage, and, secondly, because it is known that infection may attach itself to and be conveyed by the clothes of a person living in an infected atmosphere, even though the person himself remain unaffected. The same considerations will sometimes make it desirable to prohibit the attendance at school of all children from a particular street or hamlet.

In the case of infectious diseases involving little or no danger to life, such as mumps or skin diseases, school interests may be more particularly considered. In such case, however, the rule of prohibiting the attendance of every child while in an infectious state will commonly prove to be the right one; for, if disease should spread to other scholars, owing to the continuance of an infected child at the school, there will be greater ultimate loss of attendance with corresponding loss of credit to the school.

6. (*B*) Secondly, as to the closing of schools. This, by more seriously interfering with the educational work of a district, is a much more grave step for a sanitary authority to take than to direct the exclusion of particular scholars. It is a measure that seldom ought to be enforced, except in presence of an actual epidemic, nor even then as a matter of routine, nor unless there be a clear prospect of preventing the propagation of disease, such as could not be looked for from less comprehensive action. The mere fact that in an epidemic many of the sufferers are school children does not necessarily show that the disease was caught at school; but the school may with probability be regarded as spreading infection if in a large majority of households attacked the first case be a child attending school; and with still greater probability if a number of children living at a distance from one another, and with no circumstances in common except that they attend the same school, should be simultaneously attacked; and if it can be ascertained that a child or teacher in an infectious state has actually been attending the school.

7. The medical officer of health, on becoming aware of the presence of dangerous infectious disease in his district, should send immediate notice to the teachers of the school or schools which the children of infected households may be attending, requesting that such children may be excluded from school for such time as he (the medical officer of health) may specify as being necessary. The attention of school-attendance officers and of schoolmasters should also be drawn to the following considerations. Frequently they themselves will obtain the earliest information of the occurrence of infectious disease among scholars, and it is most desirable that such officer or master should without delay communicate the facts

to the medical officer of health. Absence of any child from school on the plea that it is suffering under one of the before-mentioned diseases, and absence of several children of one family from school at the same time, no matter what name be given to the complaint that keeps them at home, should be reported to the health officer. In practice it has been found that this notification of absentees has materially aided the local health officer in taking measures for the suppression of infectious disease, to the advantage alike of the district and of the school. Furthermore, schoolmasters may properly be asked to take note, especially when an epidemic threatens or is present, of symptoms occurring in any of their scholars that may indicate the commencement of disease, febrile in nature. Besides heat of skin, such symptoms are shivering, headache and langour, especially if commencing suddenly, vomiting, rashes on the skin, and sore throat. When scarlet-fever or diphtheria is about, every trace of sore throat should be looked upon as suspicious. In any case where such symptoms are observed, the safest course will be to exclude the child from school until assurance can be had that it may attend school without harm to itself or danger to other scholars.

8. As regards duration of exclusion from school of particular scholars, the time to be specified will vary in different diseases and different cases; and in this matter the sanitary authority will doubtless be guided by the advice of their medical officer of health, who may properly be intrusted with some general duty of acting for the authority in this subject-matter. Medical officers of health, having to specify a time during which any scholars are to be excluded from attendance at any school, should have regard as far as practicable to the circumstances of the particular scholars suffering from infectious disease or living in infected households. Not only the nature of the infection and the length of illness, but the environments of the individual as affecting the retention of infection, will deserve consideration. The period of exclusion, for example, will need to be different according to the conditions of a patient's lodgement, according to the sufficiency of the separation that can be effected between a patient and excluded scholars, and according to the opportunities of effectual disinfection that can be afforded to the household. Thus a hard-and-fast rule, such as has been laid down in some districts where scarlatina has been present, that no child shall go to school from any infected house for three months after the disease has begun in that house, is not to be commended. It is indeed possible that, under the circumstances of a particular household, a child convalescent from scarlatina or living in the same house with convalescents should not, in the interests of other children, be permitted to return to school until after so long a period as this; but the same ought not to be assumed of all

households in the district that may be invaded by scarlatina. The better plan would be for the sanitary authority to secure, during a shorter period, the exclusion of individual sick persons and their housemates from school; and, when that period is about to expire, to cause fresh inquiry to be made as to the expediency of further exclusion, and, if found requisite in particular cases, to cause fresh notice to be given to the school managers.

9. In deciding whether an outbreak of infectious disease among children of school age may be best combated by closing the school, or whether it will suffice to exclude the children of infected households, the two most important points to be considered are: the completeness and promptness of the information received by the officers of the sanitary authority respecting the occurrence of infectious cases; the opportunities which exist for intercourse between the children of different households elsewhere than at school.

10. The more prompt and full the knowledge of cases of infectious disease that the sanitary authority are able to obtain, the better will be the prospect of checking such disease by keeping away from school the children of infected households, and the less will be the necessity for closing schools. If the cases be few in number and their origin known, the exclusion from school of the children of infected households will probably suffice; but this measure will fail where there are many undiscovered or unrecognized cases, or where the known centres of infection are peculiarly numerous.

Commonly, the failure of carefully considered measures of exclusion to stay the spread of an epidemic which shows a special incidence upon school children may be regarded as pointing to the continued attendance at school of children with the prevalent disease in a mild or unrecognized form, and a strong case will appear for the closing of schools.

If, by reason of the absence or exclusion of a large number of children, the attendance at a school be greatly reduced, it may be found better to close it altogether. This is especially apt to occur in the case of epidemics of measles, a disease which is very infectious in the early stages, before the characteristic rash has appeared, and while the symptoms resemble those of a common cold.

11. The second material consideration, in deciding as to the desirability of closing schools during the prevalence of infectious disease, is the amount of opportunity for intercommunication between the members of different households elsewhere than at school. In sparsely populated districts, where the children of different households or of separate hamlets rarely meet except at, or on their way to, the village school, the closing of the school is likely to be effectual in checking the spread of disease. It is less likely to be useful in a town or com-

pact village (particularly where houses are sub-let and yards are in common), where the children of different households, when not at school, spend their time in playing together, and often run in and out of each other's houses. In some such places the closing of school has even appeared to do harm rather than good.

In rural districts, where epidemic diseases are less frequently prevalent, school closing may be required as an exceptional measure to meet an exceptional state of things. As regards more populous places, it must not be forgotten that, if schools were to be closed whenever an infectious disease was prevalent, there are many places where schools would hardly ever be open. It will sometimes be necessary to close a school for a day or two to allow of the rectification of sanitary defects of a nature to extend disease, or in order that the school may be disinfected or purified. It has happened that infectious sickness in the master's family has forbidden the attendance of scholars. These more temporary and occasional closures of schools are contemplated in the education code, and are to be regarded as having a real importance of their own.

12. In places where there are several public elementary schools, if an outbreak of infectious disease be confined to the scholars of one particular school, it may be sufficient to close that school only. But, where different schools have all appeared to aid in the spread of disease (though perhaps to an unequal extent), the sanitary authority may consider it advisable that all should be closed, lest children in an infectious state who previously attended the schools that are closed should be sent to others that might remain open.

It must be remembered that sanitary authorities have no power in respect of Sunday-schools or other private schools, except in so far as these may contravene section 91 (5), section 126, or other provision of public health act, 1875; but it will often be expedient to invite the co-operation of managers of such schools in efforts for securing the public health. Experience shows that they are usually ready to defer to the representations of the authority responsible for the public health of the district.

13. Reports to the sanitary authorities, advising the closure of a school or schools in any district, are to be treated as "special" reports, within the meaning of the general order of the Local Government Board of March, 1880, and copies of them should accordingly be sent to the Board. These reports should state the grounds upon which the medical officer of health advocates the closure of the school or schools in preference to the exclusion of particular scholars.

14. All notices of the sanitary authority for the closing of public elementary schools should be addressed in writing to the managers, and should state the grounds on which the closing is deemed necessary.

All such notices should specify a definite time during which the school is to remain closed; this should be as short a period as can be regarded as sufficing on sanitary grounds; a second notice may be given before the expiration of the first, if it should be found necessary to postpone the re-opening of a school. The managers of schools, after complying with the requirements of the sanitary authority, have the right of appeal to the education department, if they consider any notice to be unreasonable.

Water Supply and Sewerage.

Acting under the provisions of the act to protect the purity of inland waters, the State Board of Health has continued during the year 1891 the work required by the different sections of this comprehensive act. A portion of the duties therein specified is advisory, and others are experimental, while others still relate to the continued examination of the different public water supplies of the State.

That portion of the work embracing the advice to cities and towns with reference to water supply and sewerage was reported upon Jan. 9, 1892, in Senate Document No. 4, and is reprinted in the present volume.

The tabulated statement of chemical and biological examinations of water supplies, together with the descriptive material relative to new supplies, is a continuation of similar tabulations published in two previous reports.

The examinations of rivers reported upon in this volume relate especially to the Blackstone, Chicopee, Merrimac, Nashua and the Neponset.

Special advantages were offered during the year for river examinations in consequence of the dryness of the season during the last half of the year.

A new feature in the present report is the examination of the spring waters offered for sale in the State,—forty-five in number. Other important topics treated in this portion of the report are, "The Amount of Dissolved Oxygen in Waters of Ponds and Reservoirs at Different Depths," "The Effect of the Aeration of Natural Waters," the "Microscopical Examination of Water," and a paper upon a fresh-water organism known as Uroglena.

The experimental work performed at the Lawrence Experi-

ment Station upon the purification of sewage and of water forms the subject of a considerable portion of the report. This Department of the Board's work has proved an efficient aid in enabling it to decide many of the difficult problems relative to water supply and the disposal of sewage which are constantly being presented for consideration by the authorities of cities and towns. One proof of the value of the work of this department is shown in the frequent commendations which are received from all quarters, not only from sanitary authorities in other States, but also from the other side of the Atlantic. The results of the work accomplished at the Experiment Station already form the basis of very many of the plans which are being adopted by the cities and towns throughout the State.

This portion of the report embraces a period of two years and two months, from Nov. 1, 1889, to Dec. 31, 1891. Special consideration is given to the following subjects: the mechanical composition of the filtering material, the effect of frost, the treatment of acid sewage, and the permanency of filters.

Accompanying this part of the report are also presented certain papers upon the "Biological Work done at the Station" and the "Differentiation of the Bacillus of Typhoid Fever."

Pollution of Streams.

Upon page 57 of this volume reference is made to a communication from a citizen of the town of Canton relative to the condition of certain meadows upon the banks of the Neponset River, comprising an area of about six thousand acres, and situated in the towns of Canton, Sharon, Walpole, Norwood, Hyde Park, Dedham and Roxbury. It was alleged that the effect of keeping these meadows flowed to an unusually high level was such that "the stench arising therefrom is at times most unbearable, and the direct cause of much sickness, of malaria and kindred diseases, said to be unknown in the same locality before this state of affairs existed." The petition requested the Board to take such steps as were within its province, that the nuisance might be abated. While we are not aware that the Board has any authority to abate a nuisance of this character, it can institute an investigation, and hence immediately made such an inquiry, both through its engineering de-

partment and by means of inquiries of the various physicians living in the cities and towns upon the banks of the river within the limits of the district referred to in the petition.

Information relative to the flow of the stream and the actual condition of the waters with reference to pollution may be found in that portion of this volume which is entitled "Water Supply and Sewerage" (pages 319–336).

The following circular was sent to the physicians living in the district in question: —

OFFICE OF THE STATE BOARD OF HEALTH,
13 BEACON STREET, BOSTON, August, 1891.

Dear Sir: — The State Board of Health wishes to ascertain whether the present condition of the Neponset River and its affluents and of the Fowl Meadows has an appreciable influence on the health of the people residing in the vicinity.

The Board respectfully requests your coöperation by reporting any other information relative to the subject which you may possess.

Respectfully yours,

ROBERT W. GREENLEAF,
Acting Secretary.

In answer to this circular replies were received from thirty-one physicians, most of whom resided in or near the district at the time of receiving the circular.

The following digest of the replies from physicians practising in the valley of the Neponset River gives their opinions upon the subject: —

Canton. — "Have practised here twenty-three years. First observed effects of malaria five years ago. In one family there have been one or more cases in each season for five years. The condition of the meadows is yearly growing worse; the grass cannot be cut and is left to decay. Danger to health will increase till the meadows are drained."

Norwood. — "The Neponset River is a dirty stream and gives off an offensive odor day and night. Cannot state as to its effect on health."

Hyde Park. — "Can attribute no definite illness to this cause, but when the wind is in the right direction, at certain seasons of the year, the odor from the marshes is very strong. Its effect on invalids must be unfavorable."

"Had two cases of typhoid fever, three of intermittent fever and

four of diphtheria within a year, all near the river. Should say the condition of the river was a prime factor in their development."

"Cannot say that cases of illness can be attributed primarily to this cause, but ill-defined cases of illness, apparently malarial, are much more common here than formerly. The Neponset is yearly more and more polluted; dead fish are now carried down the current in considerable numbers; manufacturing wastes go directly into the stream with the filth of privies."

"Lived here twenty-six years. Cannot see any appreciable effect in the health of the people due to the Fowl Meadows of the Neponset."

Milton. — "Have seen two cases of malarial trouble in persons living on the Neponset marshes."

"Have had no cases of illness in the localities named which can be attributed to local conditions."

Dedham. — "Know of no evidence to show that the condition of the river and the meadows is such as to cause an appreciable amount of sickness or ill health among residents on its banks."

"Thirty years in practice. Have not noticed any unusual illness in the valley of the Neponset, as compared with other sections. Think illness there is less than in the valley of the Charles. Inspected the Neponset along the border of Dedham August 20, and found its condition, together with that of its tributaries, clean, clear and in excellent sanitary condition. The artificial drains and water courses in adjoining low lands are clogged with weeds, dead wood, dead animals and other filth. Think that individual owners should clear out these drains at their own expense. This applies to that part of the river only which is within the limits of Dedham." "Do not practice in the limits indicated. Malarial fever is increasing along the Charles at Dedham."

Dorchester. — "Know of no illness attributable to the condition of the river."

"There is a stench near Neponset bridge. Think the condition of the river might provoke intermittent fever."

"Should not think anything detrimental could be proved against the meadows on account of their remoteness from the population. Think the discharge of sewage into river near its outlet harmful."

One physician in Dorchester refers to an article in the "Boston Medical and Surgical Journal" of March 3, 1887, entitled "The Appearance of Intermittent Fever near the Neponset River," from which the following digest is taken: —

In a practice of twenty-three years the writer has not known a case of intermittent fever in Dorchester or Milton until within the previous four years, except such as were imported from malarial

regions. Have seen seven well-marked cases in four different localities, two in Dorchester and two in Milton; also two cases of uncertain character, but under the same roofs with the other cases, and suspected to be of the same nature.

First case in September, 1882, a laborer at shops where fleeces are washed. A characteristic case of tertian intermittent, an Irishman about thirty-five years old, previously healthy and able-bodied. The wool-yard in which he worked is a low tract of seventy-five or one hundred acres on Pine Tree Brook, a tributary of the Neponset. A fog often clings to this tract while air on hills around is clear. For about ten years past the brook has been dammed through a part of the year and the meadow flowed for the purpose of securing an ice harvest. A portion of the water is allowed to remain through the summer.

Second case. Female, aged thirty-three; married; previously healthy. Lived with husband and three children in the village of Milton. Taken July, 1883, with a well-developed case of tertian intermittent. The rear and west sides of this house lie close to the border of a five-acre lot of woodland of recent growth. The lot is not well drained and has standing water upon it in the cold season.

Third case, Oct. 15, 1884, on the Dorchester side of the Neponset. A married women aged thirty. Lives upon a badly drained lot of land, like the last named.

Fourth case. A seven-year-old daughter of case 2, taken ill July, 1885. Had a chill followed by fever; a second paroxysm prevented by treatment.

Fifth case, August, 1885. Man, aged fifty, in same house with Nos. 2 and 4, in another tenement. Had a succession of violent paroxysms of a tertian type with vomiting and prostration in the cold stage. He had a recurrence in 1886.

An adult son of No. 5, without chills or fever, became weak and had an aspect of malarial cachexia. He also had tenderness over the spleen.

Another child of No. 2, three years old, has had an attack, also tertian, making four or five cases in this house.

Oct. 21, 1886, a case presented itself on the southern border of Vose's grove in Dorchester, in a new house near a salt marsh. Boy three years old and form of disease quotidian. Within a day or two after the beginning of his illness an infant of fourteen months, in same family, died after an illness of several weeks, following a blow of a stone on the upper lip. There was an abscess with necrosis of a part of the bone. The diagnosis was pyæmia. The sequel suggests the possibility of malarial poison. The house is on a knoll,

partly surrounded by marsh, and within twenty feet of tide-water at highest tides. The water of the well has a marshy taste and smell.

Another case in the practice of another physician occurred in the same neighborhood, — a man employed at a coal wharf. Two of the localities involved are at the head of tide-water and near the edge of a marsh; the other three present as the only new condition, artificial obstruction by a dam or causeway to the natural drainage of adjacent soil. In two places where a plurality of cases is recorded it is probable that the well water is injuriously affected.

Four other physicians practising in Dorchester give replies which are entirely negative.

Roxbury. — "No experience of bad results. Malarial troubles are possibly due to this cause, but it is doubtful."

"Never saw a case among patients near the river which I thought could be affected unfavorably by proximity to it."

"Have had no cases of sickness traceable to the condition of the river."

Six other physicians of Roxbury give replies of an entirely negative character.

Neponset. — "There has been a decided increase of malarial troubles in this neighborhood for ten or twelve years past. Think it not due to Neponset meadows but to faulty sewerage."

Mattapan. — "Know of very little trouble that could be said to be attributed to the river. Complaints are made of foul odors from the river. Have noticed river every day. A scum appears on it like grease or soap. Dead animals are occasionally seen. The condition of the river is bad."

The Manufacture of Clothing made in Unhealthy Places.

The Legislature of 1891 enacted a law entitled "An Act to prevent the manufacture and sale of clothing made in unhealthy places." Since some of its provisions require certain duties to be performed by the State Board of Health the act is herewith quoted in full.

An Act to prevent the manufacture and sale of clothing made in unhealthy places.

Be it enacted, etc., as follows:

Section 1. Whenever any house, room or place used as a dwelling, is also used for the purpose of carrying on any process of making, altering, repairing or finishing for sale any ready-made coats, vests, trousers, or overcoats, it shall, within the meaning of this act,

be deemed a workshop: *provided*, *however*, that the exercise of such work in a private house or private room, by the family dwelling therein or by any of them, shall not of itself constitute such house or room a workshop within this definition; every such workshop shall be kept in a cleanly state and shall be subject to the provisions of this section; and each of said garments made, altered, repaired or finished for sale in any of such workshops shall be subject to the inspection and examination of the inspectors of the district police, for the purpose of ascertaining whether said garments, or any of them, or any part or parts thereof, are in cleanly condition and free from vermin and every matter of an infectious and contagious nature; and every person so occupying or having control of any workshop as aforesaid shall, within fourteen days from the passage of this act or from the time of beginning work in any workshop as aforesaid, notify the chief of the district police or the special inspector appointed for that purpose, of the location of such workshop, the nature of the work there carried on and the number of persons therein employed.

SECTION 2. If said inspector finds evidence of infectious disease present in any workshop, or in goods manufactured or in the process of manufacture therein, he shall report the same to the chief of the district police, who shall then notify the state board of health to examine said workshop and the materials used therein, and if said board shall find said shop in an unhealthy condition, or the clothing and materials used therein to be unfit for use, said board shall issue such order or orders as the public safety may require.

SECTION 3. Whenever it shall be reported to said inspector, or to the chief of the district police, or to the state board of health, or either of them, that ready-made coats, vests, trousers or overcoats are being shipped to this Commonwealth, having previously been manufactured in whole or in part under unhealthy conditions, said inspector shall examine said goods and the condition of their manufacture, and if upon such examination said goods or any of them are found to contain vermin, or to have been made in improper places or under unhealthy conditions, he shall make report thereof to the state board of health, which board shall thereupon make such order or orders as the safety of the public shall require.

SECTION 4. Whoever knowingly sells or exposes for sale any ready-made coats, vests, trousers or overcoats which have been made in a tenement house used as a workshop, as specified in section one of this act, shall have affixed to each of said garments a tag or label, not less than two inches in length and one inch in width, upon which shall be legibly printed or written the name of the state and the city or town where said garment or garments were made.

SECTION 5. No person shall sell or expose for sale any of said

garments without a tag or label, as aforesaid, affixed thereto, nor shall sell or expose for sale any of said garments with a tag or label in any manner false or fraudulent, nor shall wilfully remove, alter or destroy any such tag or label upon any of said garments when exposed for sale.

SECTION 6. The governor of the Commonwealth is hereby authorized to appoint two additional members of the inspection department of the district police force qualified to perform the duties of the members of such department.

SECTION 7. Whoever violates any of the provisions of this act shall forfeit for each offence not less than fifty dollars nor more than one hundred dollars. [*Approved May 28, 1891.*

By the provisions of the foregoing act the State Board of Health is required to issue such order or orders as the public safety may require, first with reference to the manufacture and sale of ready-made clothing made in Massachusetts (section 2), and secondly, with reference to such clothing as may be sent to Massachusetts from any place outside the State (section 3), upon information received from the chief of district police.

But one case has thus far been brought to the attention of the Board under the provisions of this act, the circumstances of which were as follows: —

On Sept. 15, 1891, a communication was received from the chief of district police stating that "ready-made clothing was being made under unhealthy conditions in a building numbered 455 Hanover Street in Boston." The Board therefore caused an investigation to be made, and found that a Portuguese woman with her nine-year-old child was living at the place in question (a tenement-house); that the child had been ill with diphtheria and was convalescent. The sick-room had been disinfected by the city board of health, which was also about to disinfect the kitchen or other room of the tenement. The tenement-house was occupied by people of several nationalities who had many children. The Portuguese woman's entire support was derived from the finishing of trousers for a clothing house in Boston. No action was deemed necessary on the part of the Board in this case, since the manufacturers of the clothing, having become aware of the existence of infectious disease in the family of their employee, declined to receive any clothing from her which had been made during the illness of the child, and until the

premises and clothing had been disinfected by the local board of health.

In comment upon this law, under which but one case has thus far been brought to the attention of the Board, it may be said that the law is liable to become inoperative, for the following reasons: 1. In consequence of the indirect methods of execution. 2. Since all questions relative to the management and control of infectious diseases are very properly referred by the existing statutes to local boards of health, who possess all the necessary power and authority to deal with them.

Every case of infectious disease occurring in a tenement-house in a family where ready-made clothing is made, or under any circumstances whatever, must by law be reported to the local board of health both by the householder and by the attending physician. There is no reason, therefore, why this question should not have been referred to the same board, under a properly framed statute.

Arsenic in Wall-papers and Fabrics.

During the past twenty years the subject of the possible danger to the public health in consequence of the common practice of using arsenic in the coloring of wall-paper and fabrics has been brought to the attention of the Legislature, and finally resulted in the enactment of a law which provided that children's toys and confectionery containing arsenic should not be made or sold. The same law required the State Board of Health to make investigations relative "to the existence of arsenic in any paper, fabric or other article offered for sale or exchange, and to report upon the same before Feb. 1, 1892."

The Board appointed Dr. W. B. Hills of the medical department of Harvard University to make these investigations, and the results of his inquiries are printed in the present report.

Noxious and Offensive Trades.

Several cases, either relating to slaughter-houses or rendering establishments, were informally brought to the notice of the Board during 1891, but no petitions having been received for hearings upon the subject, no action was taken under the provisions of the statutes relating to this class of nuisances.

Registration of Vital Statistics.

The registration of the births, marriages and deaths of the State is intrusted by law to the secretary of State, under whose charge this important department has been conducted for nearly fifty years. The work of editing the official report has been committed to the secretary of the State Board of Health for the past five years.

Since a considerable portion of the report has a definite relation to public hygiene, a condensed summary of the statistics of 1890 is herewith presented: —

The births registered in Massachusetts in 1890 were 57,777, the marriages 20,838, and the deaths 43,528. The excess of living births over deaths was 14,249.

These numbers, as compared with the living population of 2,238,-943 (United States Census of 1890), indicated a birth rate of 25.81 per 1,000, a marriage rate of 18.62 per 1,000, and a death rate of 19.44 per 1,000, and the excess rate of births over deaths was 6.37 per 1,000.

The births, 57,777 in number, were more than those of any previous year, and the birth rate, which had diminished with irregularity from 1850 to 1878, has again slightly increased. The number of still-births was 2,099.

The largest number of births, 5,338, occurred in December. The birth rate of the twenty-eight cities was 28.4, the largest being that of Holyoke, 42.7, and the least that of Newton, 21.2. The birth rate of the rest of the State was 21.7.

The whole number of marriages was 20,838 and the rate 18.62; the greatest number occurred in November, 2,505, and the least number in March, 817.

The cities having the highest marriage rate were New Bedford and Chicopee, each having a ratio of 12.5, and the city having the lowest was Pittsfield, 6.7.

The number of deaths was 43,528, which indicated a death rate of 19.44 per 1,000. The deaths of infants under one year were 9,625. The death rates have varied but little during the past forty years, the highest being 22.8 in 1864 and in 1872, and the lowest 16.9 in 1867. For the past ten years the death rate has not varied more than 1 per 1,000 from 19.5.

By counties, the highest death rate in 1891 was in Dukes and Nantucket, 25.4 and 24.5, and the lowest, 15.8, in Franklin. The greatest number of deaths, 5,300, occurred in January, and the least,

2,840, in June. Twenty-five persons died at the age of one hundred and over. By cities, the highest death rate was in Lawrence, 26.5, and in Lowell, 25.2, and the lowest, 13.7, in Newton.

The causes of death were distributed as follows by general classes: 8,079, or 18.6 per cent., were from zymotic diseases; 9,211, or 21.2 per cent., were from constitutional diseases; 19,509, or 44.8 per cent., were from local diseases; 4,396, or 10.1 per cent., were from developmental diseases; 1,814, or 4.2 per cent., were by violence, and 519, or 1.2 per cent., were from unknown or unspecified causes.

The deaths from dysentery were 220 in number, which was the least number from this cause for ten years. Those from typhoid fever were 835, which was also less than the average of the past ten years. Those from whooping-cough were 363. Those from croup were 387, from diphtheria 1,239, from measles 114, from scarlet-fever 196, which was very much less than the average of the ten years past. Those from cholera infantum were 2,491, which was in excess of the average. From small-pox, but one death was reported.

The deaths from consumption were 5,791, which indicated a slightly diminishing ratio.

From diseases of the nervous system, classified under apoplexy, paralysis, insanity and convulsions, there were 3,613 deaths.

The deaths recorded as due to heart diseases were 3,579, which was much greater than the average of the past ten years.

Special prominence is given in this report of 1890 to the vital statistics of cities, the birth, marriage and death rates being presented for the census years 1870, 1875, 1880, 1885 and 1890.

The Protection of the Sea-coast from Floating Nuisances.

The Board has received communications from two different sources during the past year relative to the existence of floating garbage of various kinds which comes ashore at certain stages of the tide and with favorable winds, causing thereby considerable nuisance in the neighborhood of such deposits. In one of these instances the nuisance consisted of floating garbage supposed to have been discharged from fishing schooners; it came ashore at Amesbury and created a nuisance there. The other complaint came from the authorities of Swampscott, the nuisance being caused by the dumping of the garbage of Boston at the outer part of the harbor; the decomposing material was driven ashore at Swampscott.

In neither of these cases did the State Board have any legal jurisdiction. It was therefore deemed best to advise the parties to seek some remedy by legislation.

With reference to the dumping of the offal and garbage of Boston at sea, there has been much improvement since the complaint above alluded to was made, as appears from the following extract from the report of the superintendent of streets of Boston for 1891: —

On investigation it was found that the complaints were well founded, since the refuse picked up on the beaches at Swampscott and its vicinity came from the Boston dumping-scow. The location of the dumping-place was therefore changed, and instead of using a single dump, as had been the custom in former years, a number of dumps were arranged, so that advantage might be taken of the wind to keep the refuse from floating ashore. These dumping-stations are shown on a chart, and are from two to eight miles farther out to sea than the old dumping-place. Since this change has been made, no complaint from any source has been received, as it is possible to choose a station from which the garbage cannot be blown ashore.

Food and Drug Inspection.

This department of the work of the Board has now been in existence nearly ten years, and has proved to be a protection against danger and against fraud.

The routine work of the Board in this direction has progressed as usual during the year. Before the close of the year it was deemed advisable by the Board that so much of the work of food and drug examination as is done in eastern Massachusetts should be under the supervision of one chemist, who should have charge of this work. Accordingly, at the annual meeting in June, 1891, Dr. Charles P. Worcester was appointed as the analyst in charge of this department of work.

An important question which came up during the year was that of the presence of copper as an adulterant in certain sorts of canned vegetables imported from France. A complaint was entered in the lower courts with reference to this form of adulteration. The defendant was convicted and appealed, but the trial in the superior court did not take place until after the close of the year embraced in this report. Hence a further account of the same will be presented in the next annual report (1892).

Municipal Health Organization.

Every year the State Board is called upon to give advice to local boards of health with reference to the proper management of sanitary matters in cities and towns, but chiefly in the smaller towns, since the cities have in most instances well-organized boards of health. The present unsatisfactory law allows any town to neglect the public welfare by intrusting the important duties pertaining to the public health of the town to a board of selectmen who are not elected in consequence of their fitness to fulfil the duties of a board of health. As a natural consequence instances of the evil results of this glaring defect are of frequent occurrence. The Board has repeatedly called attention to the need of legislation to remedy this evil, but thus far without avail.

The Weekly Mortality Reports.

The Board has maintained during nearly the whole period of its existence a weekly report of the deaths in such cities and towns of the State as have voluntarily made returns to the State Board of such deaths as occur during each week in these cities and towns. This report is compiled at the office of the Board each week, and a copy is sent to the town clerk or registrar of each city and town.

In the present report a summary is given for the year 1891, together with an abstract of the reports of the preceding eight years.

The Geographical Distribution of Certain Diseases in Massachusetts.

In this paper is presented a demographic study of eight diseases or causes of death, most of which are recognized as infectious, and preventable in a greater or less degree. The method of treating the subject is mainly statistical, and a degree of uniformity is maintained in the tabulations and groupings of counties. In the discussion of each disease the death rates from the given disease are first presented for each of the twenty years included in the period selected for observation (1871–1890). Next the death rates by counties. In addition to geographical position, the important condition of density of

population receives consideration, and finally the entire list of cities and towns in the State is presented with its general death rate per thousand of the population, and its death rate from each disease for the twenty years.

As a matter of convenience and uniformity the mortality of the State from each disease is taken as an average or standard of comparison, and is assumed to be 100.

Other special conditions receive due consideration, such as the influence of railway communication; the relation of paper mills to small-pox mortality; of employment of married women away from home to the death rate from cholera infantum; of elevation above sea level and distance from the sea to the death rate from phthisis and pneumonia.

Health of Towns.

Under this title a digest has been prepared from such reports of local boards of health as have been forwarded to the office of the State Board of Health for the year 1891. In addition to the usual matter presented, a tabular statement is given containing the number of cases of infectious disease reported to the local boards of health during the year, and the number of deaths from each of the diseases specified in the statutes so far as they were known at the time of making up the table. It would add very much to the efficiency as well as interest of this part of the report if all of the large towns were required by law to publish an annual health report.

Routine Work of the Board.

During the year ending Sept. 30, 1891, the Board held thirteen regular meetings, besides many meetings of standing committees, and five public hearings relative to questions which arose under the provisions of chapter 375 of the Acts of 1888, and certain special acts.

The mortality statistics of the cities and towns which have been voluntarily forwarded by the proper officials to the office of the Board each week have been compiled at the office and published weekly. A summary of them is presented in this report.

Much advice has been given to local boards of health relative to sanitary matters, and also to individuals who have requested

such advice; and many visits have been made by the secretary and the engineers for the purpose of inspection and advice upon such matters as have been referred to the Board for investigation.

The following table presents some of the more important work of the Board in a condensed statistical form:—

STATISTICAL TABLE FOR THE YEAR ENDING SEPT. 30, 1891.

Whole number of samples of food and drugs examined during the year,		5,294
Samples of milk examined (included in the foregoing),		2,726
Whole number examined since beginning of work in 1883,		40,965
Whole number of samples of milk examined since beginning of work in 1883,		20,732
Number of warning notices issued relative to adulteration during the year,		439
Number of prosecutions against offenders during the year,		150
Number of convictions during the year,		135
Amount of fines secured during the year,		$2,668.35
Force employed at Boston, for food and drug inspection, chemists and assistants,	4	
At Amherst,	1	
		5
Inspectors,		3
Total,		8

UNDER THE PROVISIONS OF THE ACT TO PROTECT THE PURITY OF INLAND WATERS.

[This table applies to the calendar year ending Dec. 31, 1891.]

Applications for advice from cities, towns and others:—	
Relating to water supply,	29
Relating to sewerage and drainage,	21
Relating to pollution of streams,	3
	53
Number of samples of water examined chemically and microscopically at Massachusetts Institute of Technology,	1,526
Number of samples of sewage, water and sand examined chemically and bacteriologically at Lawrence Experiment Station,	2,353
Additional samples examined bacteriologically at Lawrence Experiment Station,	580
Total number of samples examined,	4,459

Force employed at 13 Beacon Street: —		
Chief engineer,	1	
Assistant engineers,	3	
	—	4
At Massachusetts Institute of Technology: —		
Chief chemist,	1	
Assistant chemists,	4	
Chief biologist,	1	
Assistant biologist,	1	
	—	7
At Lawrence Experiment Station: —		
Chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	4	
	—	8
Total ordinary force,		19

The number of applications received since July, 1886, when the act relating to water supply and sewerage first went into operation, is as follows: —

1886,	8
1887,	22
1888,	28
1889,	38
1890,	23
1891,	53
Total,	172

Expenditures.

The expenses of the Board during the year ending Sept. 30, 1891, under the three appropriations for general expenses, food and drug inspection, and water supply and sewerage work, were as follows: —

General Expenses.

Salaries,	$5,994 96
Printing,	1,053 38
Travelling,	795 94
Special investigations,	401 62
Postage,	367 75
Books, subscriptions and binding,	334 64
Express,	298 75
Stationery,	200 99

Telephone,	$151 00
Type-writer and catalogue cases,	105 00
Chemical analysis,	66 00
Office incidentals,	82 22
Plans and maps,	23 40
Type-writing,	15 90
Advertising,	16 00
Telegrams,	2 75
Total,	$9,910 30

Food and Drug Inspection.

Salaries of chemists,	$4,700 00
Salaries of inspectors,	3,100 00
Travelling expenses and purchase of samples,	2,075 00
Legal services,	118 40
Incidentals, bottles, corks, etc.,	16 72
Printing,	9 29
Total,	$10,019 41

Water Supply and Sewerage.

Salaries,	$17,851 48
Experiment Station at Lawrence (labor, rent and materials),	5,407 78
Travelling,	875 51
Rent at Massachusetts Institute of Technology,	875 00
Express,	718 67
Apparatus,	193 71
Printing,	108 36
Stationery,	91 67
Maps and blue prints,	64 22
Paid observers,	33 00
Postage,	12 58
Telegrams,	4 76
Total,	$26,236 74

HENRY P. WALCOTT.
JOSEPH W. HASTINGS.
HIRAM F. MILLS.
FRANK W. DRAPER.
JOHN M. RAYMOND.
MORRIS SCHAFF.
ELIJAH U. JONES.

WATER SUPPLY AND SEWERAGE.

GENERAL REPORT.

ADVICE TO CITIES AND TOWNS.

GENERAL REPORT.

ADVICE TO CITIES AND TOWNS.

The following pages up to the 58th were contained in a report made to the Legislature Jan. 9, 1892, under the provisions of chapter 375 of the Acts of 1888. The portions of this report here given are the general report of the Board made under the provisions of this act, and the substance of replies made by the Board to such cities, towns, corporations and individuals as have applied for its advice relative to systems of water supply, drainage and sewerage under the requirements of the act. The portion omitted relates mainly to the work done at the Lawrence Experiment Station, a more complete account of which will be found in a subsequent portion of this volume.

During each of the years before the past one, since the Board was given the general oversight and care of all inland waters, and for the first three months of the past year, the rainfall in the State has been unusually large. This continued condition of abundant water supply and high flow in the streams has rendered scarcely noticeable the effect of the rapid growth in population during these years in exhausting the capacity of the present sources of water supply and in increasing the pollution of streams, but during the past summer and autumn a drought prevailed, which, although not as extreme as in some previous years, has indicated to many places that an additional supply of water was needed; and, as a consequence, a large number of applications have been made to the Board for its advice as to additional sources of water supply. More complaints of troubles from

bad tastes and odors have also been received during the past year than in any previous year. In nearly all cases these complaints have been accompanied by requests for examinations of the waters and information as to the character of the water, as well as for remedies to remove the trouble.

The low water in the streams of the State during the summer and autumn has been accompanied by a much greater degree of pollution in those streams which receive sewage and manufacturing wastes than has been at any time noticed since 1887. On this account special examinations have been made of the north and south branches of the Nashua River below Fitchburg and Clinton, of the Neponset River, and of the Blackstone River below Worcester. In the case of the Blackstone River the examinations were unusually complete, including, in addition to the sanitary analysis, the determination of the iron and sulphuric acid which are discharged into the streams by the iron works.

In connection with these investigations an extended series of analyses was made, to ascertain the character and degree of purification effected at the sewage precipitation works of Worcester, and the effect of this treatment on the quality of the water in the Blackstone.

At Framingham several samples of sewage and effluents from the sewage fields have been examined chemically and bacteriologically, with the result of showing that the sewage was very thoroughly purified.

In addition to the systems of sewage disposal just mentioned, the town of Gardner has begun to purify its sewage by filtration through the land, and the city of Marlborough has prepared a disposal area of land which will very soon be ready for use.

The Neponset River is polluted by manufacturing wastes to a greater extent than by sewage, and has brought forcibly before the Board the need of more knowledge as to practicable methods of disposing of such wastes without polluting the streams.

During the summer of 1891 a considerable number of spring waters which are publicly sold throughout the State were collected for examination, and at the same time a careful inspection of the surroundings of the springs was made,

to discover possible sources of pollution. There is a very large sale of spring waters in some of the cities of the State, and there is also a large amount consumed in bottled form, as soda water and other effervescing drinks.

As the result of this investigation, it was found that some of the springs were situated in regions nearly or quite free from population, where the land was not under cultivation, and the chemical and bacteriological examinations of these waters showed them to be of the highest purity. Other springs were situated in populous districts, or had near them direct sources of pollution, and the water gave evidence on chemical analysis that it had, in its course, received a large amount of pollution from the drainage of houses and cesspools. In most of the springs of this character which were examined, the water showed a high degree of purification by filtration through the ground. Although in this condition the water may be considered harmless, it should be borne in mind that spring waters of this kind, which have previously received pollution, contain filtered sewage, and that there is risk in using such waters, owing to the possibility arising at any time of imperfect purification. Out of the forty-three spring waters examined, twenty-three were at the time entirely satisfactory. The remaining twenty waters, which had previously received pollution from a moderate to an excessive degree, were found to have been purified to such an extent by filtration through the ground that at the times of observation they could not be regarded as injurious. A detailed account of these investigations will be given in the forthcoming annual report of the Board.

The Board has given much attention during the past year to the study of epidemics of typhoid fever, to determine whether they were due to infected water supplies. The question of the cause of epidemics is one of the most important at present before the Board, which is now equipped with expert biologists and chemists who have become qualified by experience to undertake investigations of this character.

In the selection of samples of water for monthly examination during the past year, attention has been largely directed to the effect of storage on surface waters under different conditions. Two hundred and five examinations of samples

of water collected from the inlets and outlets of old and seventy-two similar examinations of new storage reservoirs have been made. Many examinations of the character ot the water at different depths in reservoirs have also been made, especially as regards the presence and amount oı dissolved oxygen, with important results.

It is gratifying to note the increasing confidence with which the work of the Board in regard to water supplies is meeting with sanitarians and engineers, not only within the State but throughout the United States and in foreign countries. Applications for assistance and advice from water boards in Massachusetts are yearly becoming more numerous.

The chemical and biological laboratories have been maintained at the Massachusetts Institute of Technology, where 1,526 samples were examined chemically and microscopically, and many waters were examined for bacteria.

The following classification includes the waters, of which, in most cases, complete analyses were made, and does not include many special investigations, such as the determination of dissolved oxygen at different depths in reservoirs: —

Analyses of samples: —		
From inlets and outlets of old storage reservoirs,	205	
From inlets and outlets of new storage reservoirs,	72	
From new reservoirs,	52	
At different depths in reservoirs,	64	
Miscellaneous,	630	
Total from regular water supplies,		1,023
For new sources of water supply,	71	
With reference to pollution of streams,	250	
With reference to sewage purification,	77	
Spring waters,	43	
Town pumps and wells,	14	
In connection with study of epidemics,	48	
		503
Total,		1,526

For the coming year the Board proposes to continue the regular monthly examinations of many of the water supplies of the State, selecting as the supplies to be examined those which are used by the larger populations, or which will furnish information of the greatest value. The selections will

also be made as in the past both with reference to obtaining a record of the quality of the water used by the different communities, and to increasing the existing knowledge as to the relative quality of waters obtained or stored in different ways.

It is also desired to know more definitely than at present whether water from a polluted source, which, after filtering through the ground, is found by chemical analysis to have all the organic matter removed from it by filtration, is also pure from a bacterial stand-point. It is further proposed to add data to the map of normal chlorine of Massachusetts, for it is on this normal chlorine that all our classifications of purity of waters rest, and to discover if possible whether a standard of nitrates in ground waters can be established, which would be of great value in classifying these waters.

It is desirable that complete mineral analyses of many of the water supplies of the State should be made, for the light which they may throw on the presence of particular organisms in waters of different composition.

It is proposed to make further examinations of the methods used and results obtained in the purification of sewage by filtration through the ground and by chemical precipitation in all the towns and public institutions having systems of sewage disposal.

As a means of diminishing the pollution of rivers, the purification of manufacturing wastes before they are allowed to enter streams is also a highly important matter for investigation.

The investigations at the Lawrence Experiment Station have continued during the past year, and, as in previous years, they have related largely to the purification of sewage and water by intermittent filtration. In addition to this work, however, a very large amount of chemical and biological work has been done at the convenient laboratory of the Board, which is carried on in connection with this station. This additional work has related to the identification of different species of bacteria found in sewage, and in water supplies polluted by sewage, with a view both to detecting the presence of the pathogenic bacteria, and whether such bacteria, and others which are common in

sewage, will survive when the sewage is highly diluted by being turned into a stream

The other examinations made at this station relate to the pollution of streams, the purification of manufacturing wastes and the examination of water from many sources, a large proportion of them in connection with the study of epidemics of typhoid fever and other diseases. In all, 2,347 samples have been examined both chemically and bacterially, and bacterial examinations only have been made of 580 additional samples of water.

A more extended account of the work done at this place is given in a subsequent portion of this report.

ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," the Board is required "from time to time to consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby. It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage: *provided*, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. All such authorities, corporations, firms and individuals are hereby required to

give notice to said Board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and sewage; *and all petitions to the Legislature for authority to introduce a system of water supply, drainage or sewerage, shall be accompanied by a copy of the recommendation and advice of the said Board thereon.*"

During the year 1891 the Board has given its advice to the following cities, towns, corporations and individuals who have applied for such advice under the provisions of the general act of 1888, or under special acts relating to water supply and sewerage.

Applications were received from the following sources during the year for advice relative to water supply: Quincy; Haverhill; I. B. Little and others of Merrimac; Lot Phillips and others, relative to a supply for the towns of Hanover and Norwell; Easthampton (three applications); Orange; Waltham; Geo. W. Parkes and others of Falmouth; D. W. Tenney and others of Methuen; the Lexington Water Company; Winchester; the Stockbridge Water Company (two applications); Webster; the Attleborough Fire District, No. 1; Kingston; Fitchburg; the Marblehead Water Company of Swampscott; Wellesley; C. L. Goodhue, relative to a water supply for the village of Willimansett; Taunton; West Boylston; Clinton; Pittsfield; Millbury; Lowell; and Westminster.

The applications relating to sewerage and sewage disposal were from the following sources: Pittsfield; Fairhaven; Brookfield; North Adams; the Massachusetts School for the Feeble-minded; Amherst; Watertown; Hull; the Nemasket Mills; West Springfield; Springfield (two applications); Revere (three applications); Westborough; Wellesley College; the Massachusetts Hospital for Dipsomaniacs and Inebriates; Nantucket; Easthampton and Southbridge. To these should be added an application from the town of Beverly, which was not received till late in 1890, and a reply was made early in the following year.

Three applications were received which had reference to the pollution of inland streams. The subjects referred to in these communications were the condition of certain

meadows on the Neponset River, the widening of Alewife Brook, a tributary of the Mystic River, and the condition of the Blackstone River below Worcester.

Applications from West Boylston, Clinton, Pittsfield, Lowell, Southbridge, Springfield and Revere, received late in the year, are now under consideration by the Board.

WATER SUPPLY.

The following is the substance of the action of the Board in reply to applications relative to water supply: —

QUINCY. The mayor of Quincy applied to the Board for its advice (Jan. 5, 1891) relative to a proposed water supply for the city, from territory located mainly in the town of Braintree. The existing water supply of the city being furnished by a water company, a public hearing was given by the Board February 3, at which the city and the water company were represented. The Board, after considering the question, submitted the following reply: —

BOSTON, March 11, 1891.

It is impracticable, with the information which has been presented, to give a final judgment as to the quantity of water which Quincy can obtain from the ground bordering the Blue Hill River in Braintree in the vicinity of the outlet of Great Pond; but it seems improbable that a supply for thirty thousand people can be obtained at this place, unless a considerable proportion of the water filters into the ground during the summer from Great Pond, which has already been taken by the towns of Randolph, Holbrook and Braintree for water-supply purposes. The quality of the water taken from the ground as proposed has not been tested, but there is little doubt that the natural supply from the ground here would be excellent.

The proposed storage reservoir is so large in proportion to its watershed that the water in it would be replaced, on an average, only once in nineteen months; and it is improbable that it would furnish water of satisfactory quality for the direct supply of the city, if it was not carefully prepared at a considerable expense by removing all vegetable matter from its bottom and sides.

The feasibility of replenishing the ground water supply with the stored water will depend much upon the character of the ground, which has not yet been determined.

If it should be granted that the city of Quincy should introduce

an independent supply of water, this Board is of opinion, in view of the above considerations, that further investigations should be made before a final decision is reached relative to the construction of works for supplying water from this source; such investigations, however, cannot be made in season for presentation to the Legislature this year.

We know of no other territory within a reasonable distance from Quincy from which it is at all probable that a supply independent of the present one can be obtained; and it is also true that this territory is a more appropriate source of supply for Quincy than for any other community.

The rights of Randolph, Holbrook and Braintree to the water of Great Pond should not be infringed upon; but the city of Quincy would be more likely to obtain a sufficient supply if it could obtain from these towns the right to use to some extent the storage capacity of this pond.

The water furnished from the storage reservoir of the Quincy Water Company, which is now the main source of supply for the city, is derived from a territory having a very small population; but its quality is not satisfactory, on account of the large amount of organic matter which it often contains, and the bad taste and odor which it has at times; moreover, it is liable to pollution from the piggeries and barns upon the watershed. It is entirely practicable to remove many of the objectionable characteristics of this water, and to greatly improve its quality. The quantity to be derived from this source is sufficient for the present wants of the city.

HAVERHILL. The mayor of Haverhill applied to the Board (Feb. 4, 1891) for advice relative to the taking of certain ponds within the limits of that city as sources of water supply, to which the Board replied as follows: —

BOSTON, March 3, 1891.

The State Board of Health has considered the application of the city of Haverhill for advice in regard to obtaining a supply of water for domestic and other purposes from Kenoza Lake, Round Pond, Plug Pond and Crystal Lake, within the limits of said city.

The water from each of these ponds was analyzed by the Board in 1887 and 1888, and was found to be of satisfactory quality, with the exception of that from Plug Pond (Lake Saltonstall), which is being polluted by the rapidly increasing population upon its drainage area, to such an extent that in the judgment of the Board it should be abandoned as a source of supply.

The quantity of water in the three remaining ponds will meet all requirements for a long time in the future.

The Board concludes that Kenoza Lake, Round Pond and Crystal Lake are the most appropriate sources of supply for the inhabitants of the city of Haverhill.

MERRIMAC. Citizens of the town of Merrimac applied to the Board (February 9) for its advice relative to taking a water supply from the valley of Cobbler's Brook in that town, to which the Board replied as follows: —

BOSTON, March 25, 1891.

The State Board of Health has considered your application with reference to a proposed water supply for the town of Merrimac, to be taken from wells in the valley of Cobbler's Brook above the main village.

In the absence of borings to determine the character of the ground and a knowledge of the exact location of the proposed wells, it is not feasible to give definite advice with reference to the appropriateness of this source of supply with regard to either quantity or quality. The Board can, however, advise in a general way that this is the first source to investigate with reference to obtaining a supply of water for the town of Merrimac. If sufficiently porous material from which to obtain a supply can be found near Cobbler's Brook a half mile or more above the depot, the quality of the water will undoubtedly be excellent; but if, in order to obtain a sufficient supply, it should be necessary to locate nearer the village, the question of the quality of the water should receive further consideration.

HANOVER and NORWELL. Citizens of these towns applied to the Board (February 6) for its advice relative to the question of obtaining a water supply from Abington and Rockland, the supply to be taken by purchase from the existing supply in use in those towns. To this application the Board replied as follows: —

BOSTON, Feb. 12, 1891.

The State Board of Health has considered the proposition for obtaining a supply of water for the towns of Hanover and Norwell by the purchase of water from Abington and Rockland.

The supply of Abington and Rockland is taken from Big Sandy Pond, and is of excellent quality. The quantity is sufficient for the present population of the four towns. When more is needed,

it can probably be obtained from adjacent ponds, by artificial channels or by filtration. This source is, in the judgment of the Board, an appropriate one for Hanover and Norwell.

EASTHAMPTON. The town of Easthampton applied to the Board (February 9) for its advice relative to certain springs and streams situated in Easthampton, Northampton and Southampton, and partly upon the slopes of Mt. Tom, as means of water supply for the town. The Board replied to the application as follows: —

BOSTON, March 26, 1891.

The sources mentioned in the application are: —

1. Springs and streams located in Northampton on or near the top of Mt. Tom, at a place known as "the Old Orchard."

2. Springs and streams located partly in Northampton and partly in Easthampton, on the westerly slope of Mt. Tom, which waters flow north-westerly and empty into the Williston Mills Pond.

3. Springs and streams known as Brandy Brook and Rum Brook, located in Easthampton, on the western slope of Mt. Tom, southerly from those last mentioned and flowing north-westerly into the Nashawannuck Pond.

4. Springs and streams located in Easthampton, on the western slope of Mt. Tom, southerly from those last mentioned and flowing into Broad Brook.

5. Springs and streams known as Wilton Brook, located partly in Southampton and partly in Easthampton, said stream being now used near its mouth as a source of water supply for Easthampton.

There are three methods, as pointed out by your committee, by which a supply from these sources may be utilized by the town: —

First. The water of the brook of the Old Orchard may be diverted into the present distributing reservoir, from which it can be supplied to the town through the existing system of pipes.

Second. The sources numbered 2, 3 and 4 in your application, or a portion of them, can be utilized by means of collecting wells and a system of piping connecting with the present system in the town. These sources are at such a low level that they would not furnish a sufficient pressure for fire streams, and the present distributing reservoir would have to be maintained for this purpose. A gate or gates for connecting the two systems, and the necessary check valves to avoid back flow into the springs, would also be required.

Third. The water of Wilton Brook, taken at a point much

further up stream than at present, where it is not exposed to contamination, can be conveyed through pipes to the pump now used, from which it could be supplied to the town as at present.

No one of the suggested schemes is enough better than the others to enable a definite opinion to be reached from such investigations as it is feasible for our engineers to make, in the absence of surveys and estimates made by the town; nor is it obvious that any of the schemes will in the end be as satisfactory and economical as one providing for a supply from some source which has undoubted capacity; as, for instance, the north branch of the Manhan River above Loudville.

The Board would therefore advise the town to employ a competent engineer to thoroughly investigate the question of an improved water supply for the town. These investigations should comprise estimates of the cost of constructing and operating the works, the quantity of water which the different sources will furnish in a dry season, the length of time that the works when constructed will serve the town, and the efficiency of the service with regard to the quality of the water and fire protection.

Although the Board cannot offer definite advice at the present time as to the most appropriate source of supply for the town, it will offer some suggestions, subject to revision when it receives more accurate information. The sources which may be available n addition to those submitted by the town are the north branch of the Manhan River, already mentioned, Bassett Brook and Broad Brook.

The first of these, above Loudville, would furnish a gravity supply with nearly the same pressure as that furnished by the present distributing reservoir, and the quantity of water would be sufficient for the supply of Easthampton without storage, even if the water from the upper portion of the watershed should be diverted to supplement the present Northampton water supply from Roberts' Meadow Brook. The water of this source is probably of good quality, but has not been analyzed, because the stream at the time of examination was fed by melting snow, and the water did not have its usual character.

The water of Bassett Brook near its mouth was turbid when examined, but at the first road crossing further up stream was clear, nearly colorless, and apparently a good water. It is probable that the brook at this place would furnish a permanent supply with very little if any storage, but the water would have to be pumped, which would add to the expense. The brook does not have a rapid fall, and, upon going up the stream, before a point is reached where the elevation is sufficient to furnish a satisfactory

it can probably be obtained from adjacent ponds, by artificial channels or by filtration. This source is, in the judgment of the Board, an appropriate one for Hanover and Norwell.

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There are three methods, as pointed out by your committee, by which a supply from these sources may be utilized by the town: —

First. The water of the brook of the Old Orchard may be diverted into the present distributing reservoir, from which it can be supplied to the town through the existing system of pipes.

Second. The sources numbered 2, 3 and 4 in your application, or a portion of them, can be utilized by means of collecting wells and a system of piping connecting with the present system in the town. These sources are at such a low level that they would not furnish a sufficient pressure for fire streams, and the present distributing reservoir would have to be maintained for this purpose. A gate or gates for connecting the two systems, and the necessary check valves to avoid back flow into the springs, would also be required.

Third. The water of Wilton Brook, taken at a point much

further up stream than at present, where it is not exposed to contamination, can be conveyed through pipes to the pump now used, from which it could be supplied to the town as at present.

No one of the suggested schemes is enough better than the others to enable a definite opinion to be reached from such investigations as it is feasible for our engineers to make, in the absence of surveys and estimates made by the town; nor is it obvious that any of the schemes will in the end be as satisfactory and economical as one providing for a supply from some source which has undoubted capacity; as, for instance, the north branch of the Manhan River above Loudville.

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Although the Board cannot offer definite advice at the present time as to the most appropriate source of supply for the town, it will offer some suggestions, subject to revision when it receives more accurate information. The sources which may be available n addition to those submitted by the town are the north branch of the Manhan River, already mentioned, Bassett Brook and Broad Brook.

The first of these, above Loudville, would furnish a gravity supply with nearly the same pressure as that furnished by the present distributing reservoir, and the quantity of water would be sufficient for the supply of Easthampton without storage, even if the water from the upper portion of the watershed should be diverted to supplement the present Northampton water supply from Roberts' Meadow Brook. The water of this source is probably of good quality, but has not been analyzed, because the stream at the time of examination was fed by melting snow, and the water did not have its usual character.

The water of Bassett Brook near its mouth was turbid when examined, but at the first road crossing further up stream was clear, nearly colorless, and apparently a good water. It is probable that the brook at this place would furnish a permanent supply with very little if any storage, but the water would have to be pumped, which would add to the expense. The brook does not have a rapid fall, and, upon going up the stream, before a point is reached where the elevation is sufficient to furnish a satisfactory

pressure for fire protection, the quantity becomes too small for the supply of the town. Broad Brook will not furnish a satisfactory gravity supply, and is probably less satisfactory as a source from which to pump than Bassett Brook.

Of these three sources, further reference will be made only to the north branch of the Manhan, which appears to be the best one.

With regard to the schemes presented by the town, while either would be a considerable improvement upon the present one, it is doubtful if any of them would in the beginning furnish enough water in a very dry time, and before many years the increase in the amount of water used would require a new source of supply.

The water from the springs on the westerly slope of Mt. Tom is the best as regards quality, but the water from the other sources would probably be acceptable if not stored under unfavorable conditions.

The best method of comparing the different schemes from a financial stand-point is to determine the total yearly cost of each, including the expense of pumping, water damages, superintendence, repairs, interest, and a sufficient sum for paying the debt created by the construction of the works by the time they are outgrown. The last item is a very important one in connection with works which will be sufficient for only a few years, and may cause the yearly expense of such works to be greater than that of permanent works. After having determined the yearly cost and the capacity of the different schemes, they can then be intelligently compared with reference to the quality of the water which they will furnish, and their efficiency for fire protection.

Any new source which will fail to furnish enough water for all purposes in dry seasons, and which will thus require the maintenance and use of the present source of supply, will at such times partake of the objectionable features of the present supply.

Later in the season (September 9) the town again requested the advice of the Board as to the propriety of taking a water supply from Broad, Brandy and Rum brooks, near their junction in the south part of the town. The Board replied as follows: —

BOSTON, Oct. 7, 1891.

When the water is more completely introduced into the town, the main part of the supply, particularly during the dry weather, must come from Broad Brook, so that the quality of the water from this source is of the first importance. Samples of water

collected July 24 and Sept. 14, 1891, have been analyzed. These analyses and an examination of the whole drainage area of the brook show that the water is of very good quality for all purposes of public water supply. Owing to the rapid current of the brook, the samples contained some minute particles of suspended matter, and after rains would probably contain still more; so that it would be advisable to build a small reservoir or large well, in which the water would be nearly quiet, so that these suspended particles could settle. The water is about twice as hard as the water from Bassett Brook and the north branch of the Manhan River, but it is not a hard water. It has about the same degree of hardness as the water of the small stream which flows into your present distributing reservoir on the side of the mountain, and as the water supplied to Holyoke.

The quantity of water flowing in Broad Brook, even in the dryest seasons, will probably be sufficient for the needs of the town for a considerable time, and, with a moderate amount of storage, will meet all requirements for a very long time.

With regard to the question asked verbally, as to the feasibility of obtaining a supply from the ground at this place by means of a large well, it may be said that, if the material is porous gravel or coarse sand to a depth of twenty-five feet or more, it is probable that a sufficient supply of water of very satisfactory quality might be obtained in this way. The surface indications are not unfavorable. It would be necessary to drive test-wells to determine the character of the material beneath the surface, and to obtain samples of the ground water, before any definite advice upon this point could be given.

Another application was received from the town (October 17) relative to another source of supply not named in the last application, namely, Pomeroy Brook, to which the Board replied as follows: —

BOSTON, Nov. 4, 1891.

The quality of the water from this brook is somewhat inferior to that from other sources in the vicinity which have been examined; viz., Bassett and Broad brooks, and the north branch of the Manhan River. The natural flow of the brook in dry seasons would be too small to furnish a sufficient supply of water for your town, though a sufficient supply might be obtained by building a storage reservoir. This would not only add to the cost, but would make the water still less satisfactory in quality when compared with that of the other sources mentioned. The Board therefore concludes that Pomeroy Brook is not the most appropriate source of supply for Easthampton.

ORANGE. The committee on water supply of the town of Orange applied to the Board (February 10) for its advice relative to the appropriation of certain sources for the water supply of Orange, these sources consisting of certain ponds in the towns of Orange, Warwick and Erving; to which the Board replied as follows: —

BOSTON, March 4, 1891.

Hastings Pond in Warwick is high enough to apply water by gravity, but the quantity of water which it will furnish is insufficient for the supply of the town of Orange, and the quality of its water is not as good as that in North Pond moreover, its distance from the town would make it a very expensive source. Long Pond was not examined, but, from the information furnished by the State map and the town authorities, it seemed improbable that it would furnish enough water; and it is doubtful if its elevation is sufficient to furnish by gravity the head required for fire purposes.

North Pond by itself will furnish a sufficient quantity of water for the town for a considerable time in the future, and, in connection with that portion of Coolidge Brook which can be turned into it, will furnish a supply for a very long time. The water in this pond is soft, and of suitable quality for the supply of the town, although it is of a brownish color, owing to the drainage from swamps. The water of Coolidge Brook at the time when it was examined was of extremely good quality in every respect. Its quality may vary from time to time, but there is little doubt that it will be satisfactory at all seasons of the year.

Not only could the quantity of water which can be obtained from North Pond be increased by the diversion of Coolidge Brook into it, but its quality would also be improved; and a still further improvement can be made by diking out the swamps and diverting their waters away from the pond; and by raising the pond about two feet, if it can be done without flooding any swamp.

In view of the above, the Board is of opinion that the most appropriate source of supply for the town of Orange is North Pond, in connection with Coolidge Brook above the lowest point where its waters can be diverted into the pond; the brook to be utilized and the pond to be improved as above indicated in the beginning, if it is found practicable to do so.

If the town of Orange does not proceed at once with the construction of works, it would be advisable to have the waters of North Pond and Coolidge Brook examined, from time to time, to ascertain their quality, and more particularly to learn if the water of North Pond is subject to bad tastes and odors with which such bodies of water are sometimes affected.

WALTHAM. The city of Waltham, finding that its supply of water was becoming inadequate for the wants of its increasing population, applied to the Board (February 11) for its advice relative to the question of enlarging and deepening its filter basin, and with reference to taking three million gallons from the source now used, instead of one million gallons, which the city was then authorized to take. The Board replied to this application as follows:—

BOSTON, March 3, 1891.

The quantity of water asked for by Waltham does not exceed the share of the water of Charles River which the population of Waltham would be entitled to, if receiving as much per inhabitant as has been granted to other places on the river; but there is some question whether the river will in extremely dry seasons furnish so large a quantity for all. The quality of the water in the river is such that it should not be taken directly from the stream; but it may be taken after becoming purified as at present by slow filtration through the ground.

The character of the ground in the vicinity of the present filter basin is very favorable for obtaining a supply of well-filtered water, and the quantity can be increased to a considerable extent by deepening the basin, or by such other modification of the existing works as may be found advisable. To obtain a still larger increase it may be found necessary to adopt some means of collecting ground water at a point so far removed from the present basin that the supply will be derived from territory which does not contribute to the present works.

It is probable that some of the water which now reaches the filter basin comes from the territory on the opposite side of the river from the pumping station. A part of this territory is low and wet, and difficult to drain, being too low to enter the Metropolitan system without pumping, and the Board recommends that experiments be made to determine whether water is now drawn from this territory; if so, it should be purchased and controlled by the city. Other parts of the territory from which the supply is drawn should be sewered as carefully as possible to prevent pollution of the water supply.

To protect the filtered water from deterioration caused by vegetable growths, it is advisable to cover both the filter basin and distributing reservoir so as to exclude the light. If this is not done at present, all new works should be designed with reference to covering in the future, if it should be found necessary.

FALMOUTH. The trustees of Falmouth Highlands applied to the Board (February 20) for its advice as to the appropriateness of Long Pond in Falmouth as a source of water supply for a proposed new summer resort or village, to be located in Falmouth, between Long Pond and Buzzard's Bay. The Board replied as follows: —

BOSTON, March 25, 1891.

The State Board of Health has considered your application with reference to a water supply from Long Pond in Falmouth for a proposed village, to be located upon land now controlled by you between the northerly portion of Long Pond and Buzzard's Bay, and advises that the water of the pond is of excellent quality for domestic purposes, and is an appropriate source of supply for the territory controlled by you.

The quantity of water which the pond will furnish is very much in excess of the amount required for the proposed village; and, as it is probable that the pond may also prove to be the most appropriate source of supply for the town of Falmouth, the Board further advises that you should not obtain rights in the pond which would prevent the town from obtaining a supply from the same source in the future.

METHUEN. The town of Methuen applied to the Board (March 20) for its advice relative to a proposed water supply from Harris' pond or from driven wells in that town. The Board replied as follows: —

BOSTON, April 7, 1891.

The quality of the water of Harris' Pond is in all respects suitable for the supply of the town, and the quantity of water which it will furnish will meet the requirements of the town for a number of years. The supply from this source can be supplemented by diverting into the pond, in the spring, water from the stream which flows from North Pond, so as to supply the town for a very long time.

Another method of supplying the town would be to take water from a well or wells near the Spicket River above the village. The indications presented by an examination of the surface of this territory were sufficiently favorable to make it advisable for the town to have investigations made by some competent engineer, to determine if a supply of ground water for the town could not be obtained from this source. Water obtained in this State from the ground at a considerable distance from habitations is usually of excellent quality; but no definite advice with regard to the quantity

and quality of water to be obtained can be given until examinations of the ground have been made and samples of the water collected and analyzed. No other sources in the town seem to offer as favorable opportunities for supplying the town as those already mentioned.

With regard to the needs and interests of other communities, the Board is of opinion that the town of Methuen has the first right to any of the sources within its limits; but that, as some of the sources within the town limits may be of value to Lawrence or Haverhill in connection with other sources, the town should not acquire permanent rights beyond its present and prospective needs.

LEXINGTON. The Lexington Water Company applied to the Board for its advice (March 17) as to the propriety of improving and increasing its water supply by taking the waters of Vine Brook in that town. To this application the Board replied as follows: —

BOSTON, April 7, 1891.

The Board recognizes the imperative need of an increased supply of water for the town, and that this cannot be obtained from the territory which the water company is authorized to take and hold under the provisions of chapter 267 of the Acts of 1881.

The watershed of Vine Brook above the works of the water company, or any point above where it is liable to be contaminated by drainage from the village of Lexington, is too small to furnish enough water for the permanent supply of the whole town; but a considerable additional amount of good water can be obtained from this area by diverting into the existing wells the water of such springs and other ground-water sources as can be made available. A further increase in the quantity might be made by storing the water of Vine Brook in a small storage reservoir, which it is feasible to construct, though at a considerable cost. The Board does not advise this, however, as the quantity of water which can be stored in a reservoir of sufficient depth would increase but little the available daily supply in a dry year; and the water of the brook is so liable to contamination from the manuring of the land drained by the brook that water from such a reservoir should not be taken directly for domestic use, though it may be used after filtering a sufficient distance through the ground.

The Board would further advise that, as the problem of obtaining any considerable addition to the present supply from the territory referred to in the draft of the bill presented is a difficult one, and as some further supply will be needed before many years, the

water company should have the question of increasing the supply carefully investigated by a competent engineer.

WINCHESTER. The water board of Winchester, having constructed a new reservoir for the storage of water for the supply of that town, applied to the Board (May 1) for its advice relative to the propriety of separating the reservoir into two parts by a dam, having a pipe through which the water could be drawn at will, from the upper to the lower portion, with the view of improving the quality of the water to be furnished for domestic use. The Board replied to this application as follows: —

BOSTON, May 5, 1891.

The proposed dam will separate your reservoir into two divisions which are very dissimilar in character. In the upper division the water will cover an extensive swamp to a depth of about eleven feet, and during the summer the water will be frequently overturned to the bottom by the wind, so that the matters dissolved from the bottom will be mingled with the water, and will promote the growth of the microscopic organisms which at times cause the bad tastes and odors in stored water.

In the lower division of the reservoir, where the depth is much greater, the bottom layers of water in summer will be much colder and consequently more dense than the surface layers, and the wind will not cause the water to turn over to a greater depth than fifteen or twenty feet; consequently matters dissolved from the bottom of this division cannot at this season of the year be brought to the surface to promote growth; but organisms which grow at the surface will drop to the bottom when they die, thereby improving the quality of the upper layers, from which water should be drawn for use.

There is another consideration favorable to the construction of a dam; namely, that the full use of a reservoir like this, which has a very small watershed and consequently fills very slowly, causes large fluctuations in its level; and it is very much better that the lowering of the water should take place in the lower division of the reservoir, where the shores are abrupt, than in the shallow upper division.

In beginning to use the reservoir, the draught upon it for domestic purposes will not be enough to cause the large fluctuations in level above referred to; but the bottom layers of water in the lower division will probably become foul in summer, and it may be advisable to draw this foul water from the bottom, to

prevent it from mingling with the rest of the water, when circulation is established by the cooling of the surface water in autumn. In this case, as before, there would be a marked advantage in having a dam to retain the water to the full depth in the upper division.

In view of the above considerations, the Board is of opinion that the construction of a dam at the location of a proposed roadway across the reservoir will improve the quality of the water supplied to the town. It would be a still more satisfactory solution of the problem, if, in addition to constructing the proposed dam, some means were provided for wasting all surplus water from the upper division of the reservoir at a point below the main dam.

STOCKBRIDGE The Stockbridge Water Company applied to the Board (May 6) for its advice relative to the propriety of taking an additional supply of water from the valley at a point below their present supply, to which the Board replied as follows:—

BOSTON, June 3, 1891.

The State Board of Health has considered your application for advice with regard to taking an additional supply of water from a large well, to be sunk in the valley at a short distance below your present source of supply.

In the absence of test-wells to indicate the character of the material, and to permit a sample of water to be taken from the ground, it is not practicable to give you definite advice with regard to the quality and quantity of water to be obtained from this source. It seems probable, however, that the quality of water will not vary much from that which you now supply to the town, and that the well will furnish a substantial addition to the amount of water which you can supply from your present works.

Judging from surface indications, a well located near some springs at the northerly edge of the meadow a short distance further down the valley would be more likely to furnish the quantity of water you require.

Later in the season (October 12) the same company applied to the Board for its advice relative to the propriety of taking the waters of Lake Averic as an additional supply for the town, to which the Board replied as follows:—

BOSTON, Nov. 17, 1891.

Samples of water collected from this source in July and August, 1889, and in November, 1891, have been analyzed, and copies of

these analyses and of the analyses of other waters in the vicinity accompany this reply.

The water of Lake Averic has these favorable characteristics: that it is not polluted by any population upon its watershed, which is the most important consideration as regards the healthfulness of water. It is much softer than other waters in the vicinity, and it has very little color. Two of the samples had a disagreeable odor after the water had stood for some time. The microscopical examination of the samples collected in the summer of 1889 also showed the presence of some minute vegetable organisms, which are often found in waters which give trouble from bad tastes and odors. It therefore seems probable that this water may in certain years give some trouble in this respect, but it will probably be no more than that given by many of the ponded waters which are used as sources of water supply in the State. The quantity of water to be obtained from this source is without doubt ample for the supply of the town.

WEBSTER. An application was received from the town of Webster (May 28) for the advice of the Board relative to the appropriateness of Lake Chaubunagungamaug in that town as a source of water supply; and the Board replied that "no information had been received which would lead the Board to modify its recommendation dated Nov. 5, 1890." (See twenty-second annual report, page 13.)

ATTLEBOROUGH. The water supply committee of the Attleborough Fire District No. 1 applied to the Board (July 31) for its advice relative to a new source of water supply, and the Board, after careful consideration, and an extended investigation of other sources subsequently presented by the committee, made the following reply: —

BOSTON, Dec. 17, 1891.

In your application of July 31, 1891, you ask the advice of the State Board of Health as to the most appropriate source of water supply for your fire district, and present, as the plan which you have in view, that known as the Bungay plan in the report of Percy M. Blake, C.E., with a modification in the method of storing the water after being pumped, occasioned by the fact that you have already constructed a new stand-pipe for this purpose.

The proposed source was examined soon after your application was made, and water from the wells driven in 1886 was analyzed with unfavorable results. This fact being communicated to your

committee, you have made further requests for the advice of the Board with reference to other sources in the Bungay valley, and near the Seven Mile River; and for the opinion of the Board as to the quality of the water obtained from the source now supplying the district.

Before considering in detail the different points upon which the advice of the Board has been asked, a brief reference will be made in a general way to the requirements of Attleborough with regard to a new source of supply. The population of the town in 1890 was 7,577, and, if provision is made for double this population at the rate at which water would probably be consumed by a larger town, the consumption would then be as much as 750,000 gallons daily. It is desirable, therefore, that any new source which will involve any considerable expense should be able to furnish nearly this amount of water. Under the conditions which exist near Attleborough it is not probable that this amount of water can be obtained from any source which drains a territory of less than three square miles. The only streams near the town which drain an area as large or larger than this are the Ten Mile, Bungay, Seven Mile and Wading rivers. A supply of water might be obtained from these valleys by taking it directly from the streams, if the quality of the water would permit, or if they flow through porous land, by taking the water from wells or filter galleries sunk near them.

In general a supply taken from the ground is much to be preferred to one taken directly from the streams, because the water is clear, colorless, free from all unpleasant taste and odor, and from all suspended and nearly all dissolved organic matter. If taken from an unpolluted territory, it may also be nearly as soft as the water taken directly from the stream. Under the conditions which exist near Attleborough, it will be advisable to take a supply from the ground.

To return to the questions presented by your committee, the character of the present water supply will be considered first.

The supply is taken from a well and filter gallery with tubular wells in the bottom of each, located near the Ten Mile River not far from the middle of the town. Samples of water from this well have been analyzed from time to time since June, 1887. The well derives its supply from two sources: first, from the surrounding territory including the central portion of the town and other populated areas; and, second, from the river. The water which filters from the surrounding territory into the well is at its source more highly polluted than that coming from the river, but, owing to the distance which it percolates through the ground before

reaching the well, it is quite well purified; while that derived from the river, although less polluted in the beginning, filters so short a distance to the well that it is not as thoroughly purified. The hardness of the water is occasioned by its pollution, and will continue to increase with the growth of the town within the area from which the well derives its supply.

Samples of water have been collected on four occasions from the flowing tubular well in the bottom of the large well. The analysis of the water from the tubular well has always given evidence that this water comes from a more polluted source than other water entering the large well; but it also shows that the water is better purified by its passage through the ground.

The Board is of opinion that the water of the present source is not of satisfactory quality for the supply of the town, and that it would not be advisable to seek an increased supply at this place. It is also extremely doubtful if any large increase in the quantity of water can be obtained in the vicinity of the present well.

The first plan presented by your committee, as before stated, is the Bungay plan, reported upon by Percy M. Blake, C.E., in November, 1886. By this plan it was proposed to construct a well at the edge of the Bungay swamp, north of the village and a short distance west of the Providence Division of the Old Colony Railroad. This place is possibly open to some objection on the ground of the future pollution of the water if houses should be built upon the streets now being laid out in this vicinity; but the controlling reason for objecting to this plan is the quality of the water pumped from test-wells which had been in the ground since 1886, and also from one driven recently. For convenience the wells driven in 1886 are known as Nos. 1 and 2, and the one driven recently at this place as No. 3.

The water had a strong odor similar to that of sulphuretted hydrogen, when it was pumped from these wells; and, although colorless when pumped, it acquired considerable color after standing a day or two, owing to the oxidation of iron in it. The presence of iron was also noticeable by reason of the taste it imparted to the water. As this iron came from the adjacent swamp, and might increase rather than diminish if the water was pumped continuously, it was not considered advisable to adopt this source.

Examinations were subsequently made by driving other wells on the easterly side of the swamp. Samples from two of these were analyzed; one of them, known as Well No. 4, just east of the railroad and a short distance further from the town than the wells already alluded to, furnished water with the same characteristics as the first three wells. Another well, No. 5, much further from

the town and on the west side of the railroad and of the road leading to the Bungay reservoir, furnished water which was polluted by the drainage of a neighboring farm-house. The material at this place was not favorable for obtaining a sufficient quantity of water, so that this source does not need further consideration.

The next source suggested was on the westerly side of the Bungay swamp, and a little over a mile from the village. At this place Well No. 6 was driven through very coarse material, from which water could be pumped very freely. The mud, with few exceptions, was extremely shallow in the swamp in this neighborhood. Samples of water from this well were analyzed with entirely satisfactory results, as the water was very soft, clear, colorless, odorless, and contained very little organic matter; but the question at once arose as to whether the quality would not deteriorate when by constant pumping water was drawn into the well from the gravel beneath the swamp. To obtain some information upon this subject, two wells, Nos. 7 and 8, were driven, further out into the swamp. Well No. 7 is directly east of Well No. 6, and 860 feet from it. Well No. 8 is 1,200 feet from Well No. 6, and nearly south of it. Analyses of water from both these wells showed a much larger amount of iron than was found in Well No. 6, and in other respects showed the same characteristics as water from wells Nos. 1, 2 and 3, although to a very much less extent. As the presence of iron in this water in a soluble form is due to the lack of oxygen in the ground water, it seems possible that in pumping from this source enough air would be introduced into the ground by the fluctuations in the level of the water to oxidize the iron, in which case it would be filtered out before reaching the well. It cannot be predicted, however, with any degree of certainty, that this would happen, and, under the circumstances, it would not be advisable to choose this source without first making a long-continued pumping test, in which the water should be pumped either to the Bungay River or over the divide into Richardson's Brook, so called.

As the presence of iron has been alluded to several times as an objectionable feature, it may be well to state that the objection is not upon sanitary grounds, but because the iron would stain clothes washed in the water, and other substances with which it come in contact. A water containing iron in the form in which it comes from these wells would also be liable to promote the growth of an organism known as *Crenothrix* in the pipes.

With regard to the quantity of water to be obtained from this location, there is little doubt but that more water could be obtained than is now pumped from your present source. There is, however,

much doubt as to whether this source would meet the future requirements of the town. This question has not been thoroughly studied, because another source has since been presented, which promises to supply a larger quantity of water of satisfactory quality. This source is near the Seven Mile River, and will be considered next.

In the valley of Seven Mile River only one well has been driven, and this is known as Well No. 9. It is located on the northerly side of Orr's Pond in South Attleborough, and about 200 feet east of Seven Mile River just before it enters the pond. The quality of the water from this well is entirely satisfactory, the analysis differing but little from that of water from Well No. 6. There is this difference, however, between the two locations; that the water pumped from the ground near Well No. 6 is liable to deteriorate with pumping, while there is no reason to expect any such change in the character of water pumped from the vicinity of Well No. 9.

With regard to the quantity of water to be obtained from this source, it is hardly feasible to make any definite statement, until more extended examinations of the ground have been made. The conditions, so far as can be judged from an examination of the surface, are very favorable, as there is an abundance of porous gravel in the vicinity, the Seven Mile River flows through this gravelly land with considerable fall, and there is a very large mill pond to assist in saturating the ground. The present test-well shows the material to be coarse to a depth of twenty-five feet. If further examinations should show that this coarse material extended to a depth of fifty feet over a considerable area, there is little doubt but that the whole amount of water required for Attleborough can be obtained from the ground in this vicinity. If, however, the supply from the ground should be insufficient, there are favorable opportunities for saturating the ground by diverting the water of Seven Mile River upon it; and the water of this river receives so little polluting matter, and is so little affected by swamps, that it might be used directly in case of necessity, although it would be much less satisfactory for drinking purposes than water taken from the ground.

The Board advises that a further examination be made of the ground near the Seven Mile River in the vicinity of Well No. 9; and, if it should be found that the coarse and porous material at this place extends over a large area and to a considerable depth, this source will be the best of any investigated, and probably the best source available for the water supply of Attleborough.

KINGSTON. The town of Kingston applied to the Board (September 15) for its advice relative to the propriety of extending its filtering gallery on the bank of Jones River, in order to increase the quantity of its water supply. The Board replied as follows:—

BOSTON, Oct. 7, 1891.

The State Board of Health has carefully considered your application relating to an increase in your water supply by the extension and deepening of your filter gallery, and herewith presents its reply.

The proposed gallery may obtain its supply both from the ground water which oozes out in numerous springs from the foot of the hill and from water which may filter from the mill pond into the gallery whenever the water in the gallery is drawn down. The quality of the water coming from the land side does not differ much from that now supplied to the town from your present well, and in its present condition may be called an excellent water. The quality of the water which may filter into the gallery from the pond is uncertain. If it were feasible to place the gallery one hundred feet from the pond, there is little doubt but that the water filtered from the pond would be about as good as the spring water; but, as the gallery is necessarily placed quite near the pond, the result is, as above stated, uncertain. In view of this uncertainty as to the quality of the filtered water, it will be advisable to build a movable dam in a man-hole not very far from the well, and to keep the level of the water in the filter gallery as high as in the pond, at all times when a sufficient quantity of water can be obtained in this way. When more water is required, the dam can be lowered a little from time to time to meet the requirements. If, when the water in the filter gallery is drawn down for a considerable time, it becomes unsatisfactory in quality, a new source will have to be sought, as the supply to be obtained from the land side in this vicinity is limited.

FITCHBURG. The city of Fitchburg applied to the Board (September 30) for its advice relative to the propriety of taking the water of Meeting-house Pond in the adjoining town of Westminster, or some other available source, as an additional source of water supply. The Board replied as follows:—

BOSTON, Nov. 4, 1891.

The low condition of your reservoirs at the present time, taken in connection with the fact that this year has not been as dry as

some previous years, shows that you have practically reached the limit of capacity of your present sources of water supply, unless additional reservoirs are built on Falulah Brook.

As indicating the relation between the rainfall this year and in 1883, the following figures are given: —

Rainfall at Fitchburg.

	1883.	1891.
January to September inclusive, . .	19.64 inches	34.62 inches
June to September inclusive, . .	8.57 inches	11.78 inches
June to October inclusive, . .	13.02 inches	15.51 inches

The construction of additional reservoirs upon Falulah Brook is not advisable if it would involve much expense, because a large increase in the water supply of your city cannot be obtained without additional drainage area as well as additional storage capacity; and a large artificial storage reservoir will not furnish as good water as a natural pond, unless all soil and vegetable matter are removed from its bottom and sides at a large expense.

In examining the vicinity of Fitchburg for an additional water supply, with the aid of the new topographical map of the State, which gives the elevations of the surface, it is found that there is no territory at a sufficient elevation to feed the present high-service system by gravity, which offers as favorable opportunities for obtaining an additional supply of water as that comprising about seven and a half square miles, above the dam at Wachusett village, at the point, locally known as "The Narrows." Meeting-house and Wachusett ponds are within this area.

The dam above the narrows flows a large area of meadow, and, as a consequence, the water at the dam is inferior to that in Meeting-house and Wachusett ponds, so it will not be advisable to take water from this place at the present time.

Meeting-house Pond is favorably situated both as to the character of its shores and watershed for furnishing an excellent quality of water. There is now a larger population on the watershed than is desirable; but a chemical and microscopical examination of a sample of water collected from the pond shows that the water is still of excellent quality.

With regard to the quantity of water to be obtained from this pond, any estimate not based upon actual surveys is necessarily only a rough approximation, which will be subject to revision when the results of surveys are furnished. The best basis for estimating at present is the State map and an inspection of the locality; and upon this basis it is estimated that the pond will furnish by itself 1,200,000 gallons daily throughout the driest

year. When taken in connection with the present sources, drawing water from the pond only when the present sources will not furnish the required quantity, the yield of the combined sources in a minimum year will be about 3,400,000 gallons daily.

This amount will meet the wants of your city for quite a number of years, and may be as large an additional supply as it is advisable to introduce at present. Should you hold this view, the Board would advise that Meeting-house Pond is an appropriate source of water supply for your city. It would suggest, however, that, in view of the rapid growth of your city in recent years and the unsatisfactory quality of the water in your present reservoirs at times, it may be advisable at present or before many years to obtain a still larger supply of water from this region by drawing from Wachusett Pond also.

The Board would make the further suggestion that you consider the feasibility of laying your pipe from Meeting-house Pond by the way of its natural outlet, so that the additional supply above mentioned can be taken to the city through this pipe.

When you have determined by surveys the area of the watersheds, the area and available storage capacity of the ponds, and their elevations with reference to your present system of works, the Board requests that you submit this data to it, so that the advice herein given may be modified to suit the more accurate data furnished by you, if it should be found necessary.

In compliance with the suggestions made in the foregoing reply, the water commissioners of Fitchburg submitted the required data (December 28) relative to the watersheds of Meeting-house and Wachusett ponds, their heights and available storage capacity, and the Board then replied as follows: —

BOSTON, Jan. 6, 1892.

The State Board of Health has received from you the plans of Meeting-house and Wachusett ponds, with their respective watersheds as determined by actual surveys and data with regard to the available storage capacities and elevations of these ponds.

After a re-examination of the subject with the aid of these plans, the Board does not find it necessary to modify the advice already given in its reply to you, dated Nov. 4, 1891.

MARBLEHEAD WATER COMPANY. The Marblehead Water Company applied to the Board (October 3) for its advice relative to a proposed additional water supply from driven wells in the town of Swampscott. The Board replied as follows: —

BOSTON, Dec. 2, 1891.

The State Board of Health has considered your application, dated Oct. 3, 1891, with reference to an additional supply of water to be obtained from the ground by means of driven wells in or near Paradise Road in Swampscott, north-east of your present pumping station.

The samples collected by you from the flowing test-well and also from the five test-wells by pumping have been analyzed. The water is of very good quality. It is not quite as soft as most of the water supplies of the State, but is very much softer than the water obtained from your present wells. It is hardly feasible to tell how much of an additional supply the proposed source will furnish, because it is not definitely known how much water finds its way from this valley into your present wells. In view, however, of the good quality of the water, and the probability that you may get a considerable additional supply at a moderate cost, the Board thinks it reasonable that you should adopt the proposed source.

WELLESLEY. The Wellesley Water Board applied to the State Board of Health (October 6) for its advice relative to increasing the water supply of the town. The Board replied as follows: —

BOSTON, Dec. 17, 1891.

In the absence of investigations by means of test-wells to determine the character of the ground beneath the surface, the advice given at the present time must necessarily indicate the course of future investigations, rather than any final opinion as to the best method of increasing the supply.

Your supply is now taken from the ground, and, in the opinion of the Board, any further supply should be obtained from the same source; both because the water of the streams in the vicinity is naturally inferior in quality to the ground water, and because these streams are liable to pollution, so that their waters should not be used without being purified by filtration through the ground. It is improbable that you can obtain as large a quantity of water as you will require in the future, particularly in the summer season, from the rain which falls upon the area from which water will percolate through the ground directly to your present wells or to any well which you may build; and a part of this supply must therefore come by filtration from the neighboring streams. This requires that the new source should be located either near Charles River or Rosemary Brook. To obtain any large supply, it is necessary that the well or filter gallery should be sunk in porous material; and, judging both from the impervious nature of the material in which

your present filter gallery has been constructed, and from the surface indications along Charles River, the prospects of easily obtaining a supply in this direction do not appear favorable. Notwithstanding this fact, the Board advises driving one or more tubular test-wells in the bottom of your present filter gallery, as it is possible that a stratum of porous material might be encountered which would furnish a considerable additional supply at a very small cost.

If a test of this kind should show that it is improbable that you can obtain an additional supply in this way, a favorable location for a well may be found in the valley of Rosemary Brook just north of the Worcester turnpike and nearly opposite Longfellow's Pond. If the ground in this vicinity proves to be coarse, porous gravel, to a depth of thirty or forty feet, a large supply of water could be obtained, derived in part from Longfellow's Pond and the brook and meadow below by filtration through the ground, and in part from the territory which would naturally drain toward the well from other directions. The water stored in the interstices of the gravel around the well, and for a considerable distance down stream from it, would drain toward this well if the draft upon it in summer was large, and would assist in maintaining the supply at this time of year when the draft is greatest and the natural yield is least. If at any time the ground should become so dry from continuous pumping that the well would not furnish the required quantity of water, it might be saturated by running the water of Longfellow's Pond upon the gravelly land in the vicinity of the new well, and filtering it intermittently into the ground.

Under some circumstances it might be advisable to obtain an additional supply by means of a series of tubular wells extending up the valley of Rosemary Brook from near Williams Spring to the Worcester turnpike, or such portion of the way as might be found necessary. The choice between these two methods of obtaining a supply would depend largely upon the character of the ground as it may be found by driving test-wells.

WILLIMANSETT (a village in the north part of Chicopee). An application was received (November 6) from C. L. Goodhue for the advice of the Board relative to a proposed water supply for Willimansett, to be taken from a brook about one and one-quarter miles from the village and near the Chicopee Falls road. The Board replied as follows: —

BOSTON, Jan. 6, 1892.

It is stated in your application that it is proposed by James Emerson and others to petition the Legislature for the right to

form a company to supply the village above mentioned with water, and the proposed source of supply is said to be a brook, fed principally by springs, situated about one and one-quarter miles from the village by the Chicopee Falls Road.

The Board has caused this brook to be examined and its water analyzed. It finds that the water of the brook is at present of excellent quality, and free from all pollution by sewage. The quality is not liable to deteriorate, except by the storage of the water; and, if it is necessary to build a storage reservoir, its area should be made as small as practicable, and the reservoir should be prepared for receiving the water by removing all vegetable matter from its bottom and sides.

The quantity of water which this source will furnish in a very dry year is difficult to determine. It is undoubtedly small, but, as the village is also small, this source may meet all the requirements for as long a time as it is desirable to provide for, under the circumstances.

The Board, in its consideration of this subject, has not attempted to pass upon the question of the propriety of supplying this portion of the city of Chicopee independently from other portions of the city; but, assuming that this is proper, the Board is of the opinion that this is an appropriate source of supply for the village of Willimansett.

TAUNTON. The water commissioners of Taunton applied to the Board (November 20) for its advice relative to the question of adopting a new source of water supply, for the purpose of enabling them to dispense with the direct use of the water of the Taunton River.

BOSTON, Dec. 17, 1891.

The principal points of the plan outlined by you are as follows: the direct use of the Taunton River water is to be abandoned, but the filter basin and the pumping station located on the bank of the river are to be retained. To replace the water which is now drawn directly from the Taunton River into the filter basin, and to provide for a larger supply in the future, a gravity pipe line is to be laid from Elder's Pond to the pumping station; but, as this pond will not furnish the required additional supply, a supplementary pumping station is to be located on the shore of Assawompsett Pond, and water is to be pumped into Elder's Pond to supply any deficiency.

After describing this plan in some detail, you ask the following direct questions: —

1. Does the State Board of Health recommend the abandonment of the Taunton River as a water supply ?

2. Does the Board approve the general plan herein contained?

3. Does the Board consider that the utilization of Elder's Pond, notwithstanding its small size, is to be commended, in the way proposed, for the sake of potable and sanitary qualities?

4. Under all the circumstances, would the Board recommend some other source of supply for Taunton which does not involve Elder's Pond?

In answer to the first of these questions, the State Board of Health does recommend the abandonment of the Taunton River as a direct source of supply, on account of the great danger to health in using the water of this stream, which receives so much sewage from the city of Brockton and several large towns and villages situated upon the river or its branches. The filter basin may be retained, at least for the present, as a source of supply, provided the entrance of river water to it through pipes, or in any other way except by natural filtration through the ground, is prevented. The portion of the water which filters through the ground will probably be so well purified by such filtration that it will be of satisfactory quality. If the water from a new source should be found more satisfactory than that in the filter basin, the latter need not be used, but the presence of a considerable quantity of water in reserve near the pumping station may be of great value in emergencies.

With regard to the general plan suggested, the Board is of opinion that it is a suitable plan for obtaining an additional supply of water. The watershed of Elder's Pond, as determined by your surveys, is 340 acres, including the pond, which has an area of 145 acres. As the rainfall upon and the evaporation from the surface of the pond are nearly equal, this area cannot be reckoned upon to furnish much water. Of the rain which falls upon the 195 acres of land which remain after deducting the area of the pond, not more than an average of 250,000 gallons daily will ever reach the pond and be available for use. The yield from this source would probably be even less than this amount, because the pond is at a higher level than other ponds and streams in the vicinity, and it is situated in a gravelly territory, through which considerable water may be lost by percolation. It is obvious, therefore, in view of the small quantity of water which this pond will furnish, that it will not by itself furnish a sufficient additional supply for your city; and it is therefore necessary, if this source is to be retained, to pump water into it to maintain the supply, or some other source may be selected which will furnish the whole quantity

of water required. An ample supply of water can be obtained from Assawompsett Pond, and this might be conveyed to the existing pumping station, by gravity, by direct pumping, or by pumping through Elder's Pond. It seems probable that the cost of a gravity line would be greater than the cost of pumping, because of the very long distance that a pipe would have to be laid at a great depth below the surface of the ground; and, if pumping is necessary, it is much cheaper to pump into Elder's Pond than to pump directly, because in the former case the pumping can be done at the most convenient times and rates, while in the latter it would be necessary to pump the water about the same rate that it is used in Taunton. There is a further advantage in pumping into Elder's Pond, — that the quality of its water is better than that of the other ponds at Lakeville, and other waters pumped through it will be improved, both by mixing with the better water of this pond and by the storage of these waters in it.

The water of Assawompsett pond was analyzed by the Board four times in 1887 and 1888; and the water of the Nemasket River, above Middleborough, and only two and a half miles from the pond, was analyzed monthly for two years, ending in May, 1889. These analyses may be found on pages 172 and 226 of the special report of the Board upon the Examination of Water Supplies, 1890. A sample collected in December, 1891, has also been analyzed. The pollution caused by the small population upon the watershed is so slight that it cannot be detected by chemical analysis. The analyses show that the water is very variable in color, being at times nearly colorless and at other times having a rather high color, and a corresponding amount of organic matter, derived mostly from the swamps situated in various parts of the watershed. The water, if pumped directly from Assawompsett Pond, would be fairly satisfactory for the supply of your city; but it is capable of improvement, and it is probable that it might be improved by intermittent filtration through a sufficient area of gravelly land near the shore of Elder's Pond. This filtration is not an essential feature of the plan; but the Board would strongly advise that you make provision for it upon a limited scale, in the beginning, and, if found satisfactory, that you then arrange to filter all the water pumped into Elder's Pond. The additional annual cost of this filtration, if it should prove efficient, would be very small.

All necessary precautions should be taken to prevent the direct entrance of sewage into Assawompsett Pond, if it is taken as a source of water supply.

The third question submitted has already been answered in replying to the second one.

The fourth question, asking whether, under all the circumstances, the Board would recommend some other source of supply for Taunton which does not involve Elder's Pond, cannot be definitely answered at present, because it would require an exhaustive study of the different sources which might be used for the water supply of Taunton, and it has not been feasible to make a study of this kind in the limited time in which you desire a reply. From a knowledge of the requirements of your city, and from a general examination, partly by means of maps, of the possible sources of water supply in the vicinity of Taunton, the Board is not able to suggest any better source of supply than that which you have proposed.

The quantity of water which Assawompsett Pond will furnish is very greatly in excess of any present or probable future requirements of the city of Taunton; and the Board is therefore of opinion that, should you obtain rights to take water from this source, they should not be such as to prevent other cities and towns from taking their proper share of the water in the future.

MILLBURY. An act was passed in 1888 (chapter 404 of that year), authorizing the town of Millbury to introduce a water supply within three years from the passage of the act. This time having expired, a water company was formed which applied to the Board (Dec. 15, 1891) asking its advice as to the propriety of taking the same source as was advised by the Board for the town of Millbury in 1888. The Board replied as follows: —

BOSTON, Jan. 6, 1892.

The State Board of Health has received your application, dated Dec. 15, 1891, stating that a water company has been formed which proposes to adopt the same source as was advised for the town by this Board in 1888, and, upon reconsidering the matter, finds no reason to modify the reply as originally made, which is as follows: —

"After careful examination of the different sources of water supply for the town of Millbury, excepting that of the Worcester water works, which has been mentioned but is understood to be unavailable, the State Board of Health finds that the site selected for a ground water supply has advantages which make it the most appropriate source for the town.

"Analyses of water from the flowing well showed it to be very soft and of excellent quality.

" The quantity that can be obtained from the immediate locality

of the present well cannot be determined until proved by months of pumping, and other wells may be needed to intercept all of the water that may be required; but the surroundings indicate that a sufficient quantity, for a long time in the future, may be brought to a pumping station in the vicinity of the present well.

"The Board advises that water taken from the ground should, when stored, be in a reservoir from which light is excluded."

WESTMINSTER. A committee of the town of Westminster applied to the Board (December 26) for its advice as to the propriety of taking Meeting-house Pond as a source of supply for the town. The Board replied as follows: —

BOSTON, Jan. 6, 1892.

The Board has caused examinations of this pond and an analysis of its water to be made. The pond is favorably situated, both as to the character of its shores and the natural character of its watershed, for furnishing an excellent quality of water. The population on the watershed is larger than is desirable, but a chemical and microscopical examination of the water shows that it is still of excellent quality.

The Board is therefore of opinion that this source is an appropriate one for supplying the town of Westminster. The quantity of water which this pond will furnish is very much in excess of the requirements of your town, and the pond is so located that it is also an appropriate source of supply for the city of Fitchburg; so that, while the Board is of opinion that the town of Westminster should have the right to take as much water as it needs from this source, it is also of opinion that the rights obtained by you should not be such as to prevent the city of Fitchburg from obtaining the right to use so much of the water as is not required by your town.

SEWERAGE AND SEWAGE DISPOSAL.

The following summary comprises the action of the Board relative to systems of sewerage and sewage disposal, in reply to such applications as have been received during the year: —

BEVERLY. An application was received (Oct. 2, 1890) from the selectmen of Beverly, requesting the advice of the Board relative to a system of sewage disposal having out-

lets into the sea at several points along the shore. A public hearing was granted to all parties interested, on December 2, and was continued on Jan. 6, 1891. At the former hearing, and during the interval, considerable opposition being made to the outlets in the eastern part of the town, that portion of the plan having two outlets in the east part of the town was withdrawn by the selectmen, and the Board was requested to approve the remaining outlets. The Board replied as follows: —

The State Board of Health has considered the application of the selectmen of Beverly, as modified at the second hearing given at the State House on Jan. 6, 1891.

The request for advice, as it then stood, was solely in regard to the disposal of the sewage of portions of the town at three points, the largest quantity to be discharged at or near Tuck's point, and small quantities to be discharged below low water at outfalls marked 2 and 3 upon the plan presented.

The Board regards the outlets marked 2 and 3 on the plan, if extended so as to be covered at the lowest water, as suitable for the sections of the town to be drained by them.

The outlet No. 1 should, in the judgment of the Board, be changed by carrying it beyond low-water mark so that it will be always covered, opposite the point where the main sewer first reaches the shore near the Queen Hotel.

PITTSFIELD. The city of Pittsfield, acting under the provisions of chapter 375 of the Acts of 1888, presented a plan of sewers to the State Board of Health in 1890, providing for collecting the sewage at a point near the confluence of the east and west branches of the Housatonic River, but without indicating definitely the method of disposal. The Board finally approved the main features of the plan, May 12, 1890. Subsequently the city was authorized, by chapter 357 of the Acts of 1890, to build a system of sewerage and sewage disposal, subject to the approval of the State Board of Health. Under the provisions of this act the city again applied to the Board (March 20, 1891), presenting a plan of sewerage and sewage disposal, and stating their intention "to build portions of said general plan, with a temporary outlet into the Housatonic River, at such a point, between the junction of the trunk sewers on the west bank

of the east branch of the Housatonic River, as shown in said plan, and the junction of the east and west branches of the river, as may seem desirable. The city of Pittsfield hereby asks advice as to the place where a temporary outlet may be made into the river." After some modifications the plan was finally presented to the Board for its approval May 11, 1891, and the Board replied as follows: —

BOSTON, May 12, 1891.

The general plan for a system of sewerage and sewage disposal for the city of Pittsfield, as modified, and finally presented by your commission on May 11, 1891, under the authority of chapter 357 of the Acts of 1890, is hereby approved by the State Board of Health.

This plan provides for the permanent disposition of the sewage by intermittent filtration through the areas of upland indicated, and allows the temporary discharge of the sewage into the river at a given point, during the construction of the works; but such discharge is not to continue after June 1, 1900.

FAIRHAVEN. The selectmen of Fairhaven applied to the Board for its advice (April 11) relative to a plan of sewerage for certain public buildings and a limited part of that town, with an outlet into the Acushnet River. The Board replied as follows: —

BOSTON, May 5, 1891.

The plan submitted for the disposal of the sewage of the Rogers school, the proposed town hall and public library, and a limited portion of said town, by means of a sewer discharging into the Acushnet River at the end of Union wharf, meets with the approval of the Board.

BROOKFIELD. The selectmen of Brookfield applied to the Board (May 30) for its advice relative to a proposed plan of sewerage and sewage disposal for the village of Brookfield. To this application the Board replied as follows: —

BOSTON, July 8, 1891.

The State Board of Health has considered your application, dated May 30, 1891, for advice with regard to a proposed plan of sewerage for the village of Brookfield, intended to provide at present for the storm water from the central portion of the village and the wastes from the shoe factory, and ultimately to provide for the sewerage of a large part of the village.

The Board is of opinion that the plan presented is not the best one for the town to adopt, because the discharge of much sewage at the point proposed would be likely to create a nuisance, and seriously pollute the stream which runs through the meadow and crosses the road to West Brookfield, three-quarters of a mile below.

The town, in planning a sewerage system, should have in view the probable necessity of purifying sewage in the not distant future; and for this and other reasons it will be best not to permit any surface water to enter the sewers designed for the removal of the sewage, using independent sewers or drains for the removal of the surface water, if underground removal is found necessary.

The Board is of opinion that the best course for the town to pursue is to have the question of its sewerage re-examined by some engineer, who is competent to advise in regard to sewage disposal.

The plan made should provide in the beginning for the disposal of sewage upon land, unless the cost is too great; in which case the Board would consider a plan which provides for discharging sewage into the Quaboag River for the present, but is also arranged with reference to the purification of the sewage in the future.

NORTH ADAMS. The sewer committee of North Adams applied to the Board for its advice (March 24) upon a proposed plan of sewerage and sewage disposal for the principal part of the village of North Adams, with an outlet into the Hoosac River below Johnson's Mill. The Board replied as follows: —

BOSTON, April 7, 1891.

The State Board of Health has considered your application for advice with reference to a proposed main sewer in the town, to serve a locality known as the swamp, to intercept existing sewers which discharge into a stone drain in said swamp or into the Hoosac River, and to discharge its contents into the main river at a point below Johnson's Mill.

The Board recognizes that the construction of a sewer as proposed will greatly improve the sanitary condition of the region known as the swamp, and that the sewage will be discharged further down stream, and under somewhat more favorable conditions, than heretofore. It also recognizes that the amount of sewage now entering the river at North Adams and Adams is large, and increasing with the extension of the sewers in streets or districts not heretofore sewered and with the increase of population; so that the time is close at hand when the river will be so much

polluted that it will be necessary to purify the sewage. This purification can be accomplished either by the intermittent filtration of the sewage through porous land, or by precipitating the solid particles contained in the sewage with chemicals. In either case the purification can be best accomplished below the outlet shown on the plan submitted; and the sewer should be constructed with a view to its extension in the near future to the locality best adapted for the purification of the sewage.

We are informed that sewers already built in North Adams have been designed to exclude surface water, and that it is proposed to continue the same plan with reference to the sewer now proposed. This is a wise provision in places like North Adams, as it permits the use of smaller main sewers than could otherwise be adopted, and lessens the difficulty and cost of purifying the sewage.

The Board approves the proposed plan as a temporary expedient to meet pressing sanitary needs, and as a part of a main sewer to convey the sewage of the town to future purification works.

THE MASSACHUSETTS SCHOOL FOR THE FEEBLE-MINDED. The trustees of this institution applied to the Board (April 23) for its advice as to the disposal of the sewage of a second group of buildings upon their land in Waltham, the proposed mode involving disposal by filtration upon a tract of about two acres. The Board replied as follows: —

BOSTON, June 18, 1891.

The land suitable for sewage disposal consists of a generally flat area on the north-easterly side of the driveway leading to the school, and a somewhat narrow strip which slopes from the driveway down to the meadow on the south-westerly side. The flat area is the most available for sewage disposal, and consists mainly of porous gravel covered with black loam and yellow subsoil. In portions of the area this covering is from one and five-tenths to two feet deep. In making use of this land it will not be desirable to use any portion of it within ten feet of the street, or within one hundred feet of any house; and a small strip adjoining the hill should also be excluded because of its impervious nature.

The area of porous land required to dispose of the sewage from this group of buildings in a satisfactory manner is estimated to be one acre; and it seems doubtful if this area can, under the limitations above given, be obtained without utilizing a portion of the sloping land on the south-westerly side of the driveway.

Where the sewage is applied to the surface, as proposed by you,

it is essential, in order to prevent all offence, that it should be put upon the land while fresh; that the surface to which the sewage is applied should be porous, so that the liquid will quickly settle into the ground; that the quantity applied to any particular part of the land should not be excessive, and that the sewage should be applied intermittently. It is also necessary that all tanks and carriers should be so designed and cared for that they will not become foul.

The Board suggests the following general plan as one which will meet these requirements: a separating tank to be provided to receive the sewage as it comes from the buildings, and retain solids which are heavier or lighter than the water, these to be disposed of, as at the present tank on your grounds. From this tank the sewage should be carried to the filtration area in pipes and by open carriers or troughs, so constructed that they will not become offensive. This area to be divided into not less than four sections, each containing a series of trenches one foot wide and of sufficient depth to reach the porous material, spaced five feet apart and having a gentle slope; one foot fall in fifty will answer, but the slope may be greater or less than this. The trenches to be filled with coarse sand or gravel to within about four inches of the surface. The different sections to be used in succession, so as to insure a proper interval between the applications. Provision to be made for distributing the sewage equally among the trenches in any given section. Underdrainage will not probably be necessary, but the surface water from the side hill above the trenches should be diverted from them.

AMHERST. The selectmen of Amherst applied to the Board (May 8) for its advice relative to the disposal of the sewage of a portion of the town into Fort River. The Board replied as follows: —

BOSTON, June 18, 1891.

The State Board of Health has carefully considered your application for advice with regard to the disposal of the sewage of that portion of Amherst now draining through the Snell and Fearing Brook sewers. The plan presented proposes to unite the sewage from these two systems and convey it directly to Freshman or Fort River, where it passes through land of E. Hastings, not very far above the New London Northern Railroad.

With the growth of the town it will probably become necessary to purify the sewage by intermittent filtration through land before it is discharged into the river; but for the present the

Board advises that the sewage be passed through a properly designed settling tank, the outlet pipe of which turns down at its entrance, so as to allow only those parts of the liquid which lie between the deposits at the bottom and the floating matter at the surface to enter it and be discharged into the river. The tank should be provided with another pipe, closed by a gate, through which the deposited and floating materials may be drawn to an area of sandy land at a lower level, where, after draining, the deposit may be turned under the surface or otherwise disposed of. This tank should be thus flushed out as often as twice in a week.

WATERTOWN. The town of Watertown is within the district defined in the Metropolitan sewerage act (chapter 439 of the Acts of 1889). Having devised a plan of sewerage involving discharge of its sewage into that portion of the Metropolitan sewer which has its outlet into the main drainage system of Boston, the sewer commission of Watertown applied to the Board for its advice as to the proposed plan. The Board replied as follows: —

BOSTON, June 18, 1891.

Your application for advice in regard to a system of sewerage for a part of the town of Watertown, submitted May 26, 1891, together with outlines of your proposed plan, has been considered by the State Board of Health. The outlines presented indicate that certain districts of the town are to have their sewage brought into the proposed Metropolitan sewer at Galen and Water streets. The Board advises that this is a suitable disposal of the sewage of the district indicated.

The essential features of the plan in other respects are not given in sufficient detail to enable the Board to give advice as to these, further than to suggest that you have your engineer consider whether it would not be preferable to use, instead of the twenty-four-inch siphon across Charles River, two smaller pipes, either one of which could more readily be flushed and kept clean than one large pipe.

In constructing your system of sewerage, it is very important that all rain water both from the surface of the ground and from roofs should be wholly excluded, and that every effort should be made to prevent the entrance of ground water. This restriction is important, not only on account of the cost of pumping, but even more so on account of overburdening the Metropolitan system, and requiring its duplication at an earlier date than would otherwise be necessary.

The Board is therefore of opinion that, if it shall be found necessary to convey away ground water or surface water by a separate system, an additional expenditure for thus restricting the quantity of liquid entering the sewers would be warranted not only on account of the joint interest of Watertown in maintaining the Metropolitan system in an efficient condition for as long a time as possible, but also because the annual charge to the town for the use of the Metropolitan system should be influenced by the amount of sewage furnished.

On July 1 the sewer commission of Watertown requested that the Board would indicate what details were required, in order that the Board might take further action upon the application. To this request the Board replied as follows: —

BOSTON, July 10, 1891.

Your letter of the 1st instant was laid before the Board at its meeting July 7, and by it referred to the committee on water supply and sewerage. The Board included in its reply to the town the statement that "the essential features of the plan in other respects are not given in sufficient detail to enable the Board to give advice as to these," in order to place the facts upon record, and show that it has neither considered nor approved any of the general features of the system of sewerage presented, with the exception of the outlet. The most important omission was the absence of any statement upon the application or indication upon the plan as to the system of sewerage to be adopted; that is, as to the extent that rain water and ground water were to be kept out of the sewers. With regard to these features the Board expressed its opinion quite fully in the reply sent you. If the plan had shown the inclinations of the principal sewers, and their elevations as compared with the surface of the ground and with the Metropolitan sewer, the general features of the plan would have been more intelligible, and the Board might have offered some advice or suggestion as to these. These details, however, are generally left to the engineers employed by the town.

HULL. The selectmen of Hull applied to the Board (June 4) for its advice relative to a proposed sewer for that part of the town which is in the neighborhood of Stony Beach. The Board replied as follows: —

BOSTON, June 18, 1891.

The Board advises that the sewer outlet at low-water mark on the North Shore, as indicated upon the plan submitted by you

June 4, 1891, is suitably located for disposing of the sewage of the small portion of Hull in the vicinity of Stony Beach.

THE NEMASKET MILLS. The owners of the Nemasket Mills, intending to erect a new mill upon the bank of the Taunton River at East Taunton, applied to the Board (June 9) for its advice as to a plan for the disposal of the sewage of the mill. The Board replied as follows: —

BOSTON, August 5, 1891.

It is understood that you propose to keep the wash water flowing from the sinks entirely separate from other waste matters, and conduct it by a suitable system of pipes to a tight cesspool, with an overflow therefrom into a filtering trench on the bank of the river. It is further understood that privies are to be provided, in which all excrementitious matters both solid and liquid are to be retained in a water-tight vault, to be cleaned from time to time. If these plans are carried out, and the deposits removed from the privy vaults are buried in the ground, not less than one hundred feet from the river, the Board is of opinion that the water supply of the city of Taunton will not be contaminated by your works.

WEST SPRINGFIELD. The selectmen of West Springfield applied to the Board (June 11) for its advice as to the propriety of discharging sewage by means of a three-foot sewer into the Connecticut River. The Board replied to this request as follows: —

BOSTON, June 27, 1891.

The State Board of Health has considered your application, dated June 11, 1891, with reference to the discharge of sewage into the Connecticut River at a point about seven hundred feet north of North End Bridge in your town, and is of opinion that the sewage of so much of the town as can be drained in this direction may for the present be discharged into the river at this place. The Board advises, however, that provision should be made for discharging the dry-weather flow of sewage into the river by means of a pipe of moderate size, extending from the bottom of the sewer to deep water.

SPRINGFIELD. The city of Springfield applied to the Board (June 17) for its advice relative to a proposed sewer to be constructed through Wason Avenue in the northern part of Springfield to the Connecticut River. The Board replied to this application as follows: —

BOSTON, June 27, 1891.

The application made by you, June 17, 1891, giving notice of the intention of the city to introduce a system of sewerage in the northerly part of Springfield, having its outlet into the Connecticut River on the line of Wason Avenue extended, has been considered by the State Board of Health. It is stated, on the general plan of the city, accompanying the application, that "the dry-weather flow of sewers discharging into the Connecticut River is to be carried by small submerged pipe outlets into deep water in the river." With the understanding that the proposed sewer is to be provided with an outlet of this character, discharging the dry-weather flow well out from the shore, the Board advises that the proposed method of sewage disposal for this district is adapted to the present needs of the communities affected thereby.

REVERE. The selectmen of Revere again applied to the Board (July 29) relative to a proposed system of sewerage, "to be so laid that sewage shall be discharged by gravity into tide waters, at several points within the town, as follows: Belle Isle and Sales and Mill creeks, so called, and Pines River." The Board made the following reply: —

BOSTON, Sept. 2, 1891.

The State Board of Health has carefully considered your application of July 29, 1891, relating to the disposal of the sewage of the town by discharging it by gravity into Mill Creek below the tide mill, into Sales Creek below Winthrop Avenue, into Belle Isle Inlet west of the Revere Beach and Lynn Railroad, and into Pines River. The first three of these outlets are unsatisfactory on account of the small amount of water to dilute the sewage, the sluggish currents, and the area of flats laid bare at low tide. The discharge of sewage at these creeks would also tend to pollute the waters of Chelsea River and the upper portion of Boston harbor, which it is one of the purposes of the Metropolitan system of sewerage, now under construction, to keep free from pollution. The Pines River near its outlet is a more favorable place for discharging sewage than the others mentioned; but an outlet here should be considered only for Oak Island and the peninsula northerly therefrom, as these places may not be sewered to a more favorable outlet at a reasonable cost.

Aside from any question as to the suitability of the proposed outlets, it is improbable that any satisfactory system of sewerage for the whole of the settled portions of your town can be devised

which will not require a part or the whole of the sewage to be pumped. The Board would therefore advise the town to consider the feasibility of disposing of its sewage by pumping into the ocean at a considerable distance from the shore, or by connecting with the Metropolitan system of sewerage.

In making such investigations, the Board would call your attention to its advice contained in its report to a committee of citizens of Revere, published on page 18 of the twenty-second annual report of the State Board of Health.

On October 21 the committee appointed by the town again applied to the Board, at the same time suggesting three plans for consideration, and asking for a hearing by the Board: —

1. The plan of 1889, having an outlet at Ocean Pier.
2. The plan providing for outlets into the creeks and marshes.
3. The plan having an outlet into the Metropolitan sewerage system.

In compliance with the request of the committee, a hearing was held November 17, and the following reply was made by the Board: —

BOSTON, Dec. 2, 1891.

In compliance with a request contained in your application of Oct. 21, 1891, and your further communication dated November 7, the State Board of Health gave a hearing to your committee on November 17, and, having carefully considered the plans submitted, herewith presents its reply.

The first plan presented is a modification of the one contained in a printed report dated May, 1889, of the committee on sewerage of your town. It provides for pumping the sewage from nearly the whole of the town into the ocean during the first portion of the outgoing tide, through a pipe carried out about one thousand feet beyond the outer end of Ocean Pier. The sewage of the northerly part of the beach is provided for by an independent outlet into Pines River. Other methods of disposal are suggested for several marginal streets or small districts in the town, the general method being by gravity into the neighboring creeks.

The second plan propóses the discharge of the sewage by gravity, for the present, into Sales Creek or the portion of Belle Isle Inlet west of the Revere Beach & Lynn Railroad; and, in the future, the extension of the system by a main sewer discharging by gravity into the Metropolitan sewer at Breed's Island, or possibly

at Chelsea. This plan is described in writing, but no details are mentioned except with regard to the grade of the main sewers. The inclination given to the sewers from the centre of the town near the water works pumping station and from Ocean Avenue near Beach Street to the proposed temporary outlet is so small that the sewage matter would deposit in the sewers, rendering them unsanitary, and finally inoperative. The proposed extension to the Metropolitan sewer at Breed's Island has the same defect with regard to low inclination, and the further disadvantage that the outlet into the Metropolitan sewer is placed at so low a level that after a few years the depth of the sewage in this sewer would be sufficient to back the sewage up in the Revere sewer, and still further increase the tendency to fill it with sewage deposits.

These defects were stated to your committee at the time of the hearing, and the member who originated this plan has since modified it by lowering the temporary outlet to the level of mean low tide, thereby giving the main sewers which have been mentioned a fall of five feet to the temporary outlet. The lowering of the sewers to this extent would be objectionable, as the sewage would be backed up in them nearly all of the time; and even when the tide is low the sewers have so little fall that the current in them would be insufficient to remove the sewage matter which was deposited when the tide was high.

In addition to these objections which are made to the sewers as proposed, the Board is of opinion that these creeks are not suitable outlets for the sewage of any considerable portion of your town, as indicated in the following reply, dated Sept. 2, 1891, to your board of selectmen: —

"The State Board of Health has carefully considered your application of July 29, 1891, relating to the disposal of the sewage of the town by discharging it by gravity into Mill Creek below the tide mill, into Sales Creek below Winthrop Avenue, into Belle Isle Inlet west of the Revere Beach & Lynn Railroad, and into Pines River. The first three of these outlets are unsatisfactory on account of the small amount of water to dilute the sewage, the sluggish currents, and the area of flats laid bare at low tide. The discharge of sewage at these creeks would also tend to pollute the waters of Chelsea River and the upper portion of Boston harbor, which it is one of the purposes of the Metropolitan system of sewerage, now under construction, to keep free from pollution. The Pines River near its outlet is a more favorable place for discharging sewage than the others mentioned; but an outlet here should be considered only for Oak Island and the peninsula northerly therefrom, as these places may not be sewered to a more favorable outlet at a reasonable cost.

"Aside from any question as to the suitability of the proposed outlets, it is improbable that any satisfactory system of sewerage for the whole of the settled portions of your town can be devised which will not require a part or the whole of the sewage to be pumped. The Board would therefore advise the town to consider the feasibility of disposing of its sewage by pumping into the ocean at a considerable distance from the shore, or by connecting with the Metropolitan system of sewerage.

"In making such investigations, the Board would call your attention to its advice contained in its report to a committee of citizens of Revere, published on page 18 of the twenty-second annual report of the State Board of Health."

The first plan presented, viz., that of disposal by pumping at a point one thousand feet beyond the Ocean Pier, appears to this Board to be in its general features a reasonable solution of the sewage problem of the town. An outlet at or near the point proposed, through which the sewage would be discharged after being screened, during the first portion of the outgoing tide, would, in the judgment of the Board, prove satisfactory. Pumping the sewage at or near the proposed location of the pumping station permits the sewage to be collected from a large portion of the town, including all the principal villages and a large portion of the beaches, by sewers having sufficient inclination so that they can be kept clean with a moderate amount of care.

In commending this plan, the Board has not considered details, such as the exact location of the outlet, nor the propriety of turning the sewage from marginal streets and small districts into the neighboring creeks, rather than into the general system; and, should the general features of the plan be adopted, these features should be again presented for the advice of the Board.

Another way of securing an outlet as good or better than the one provided by the plan last mentioned is to connect with the Metropolitan sewerage system. The plan for connecting with this system should be considered by the town in comparison with the system last mentioned. It is possible that the Chelsea branch of the Metropolitan system might be lowered, enlarged and extended to Revere, so that the sewage of the town could be turned into it by gravity. This would require a smaller inclination in some of the town sewers than is provided by the pumping system, and would make it more difficult to keep them clean; or the inclination required for discharging the sewage by gravity might prove to be so small as to be inadmissible, and pumping might still be necessary for a portion of the beaches. Even if no pumping is required in the town, the sewage would have to be lifted twice at the pump-

ing stations on the line of the Metropolitan sewer, so that the town would have to pay for pumping in any case.

Another method of connecting with the Metropolitan system would be to collect the sewage of the town, perhaps at your proposed pumping station, and pump it to the Metropolitan sewer on Breed's Island. It is possible that this might be cheaper than lowering, enlarging and extending the Chelsea branch, and pumping at East Boston.

The Board cannot at present give any definite advice with regard to a connection with the Metropolitan system, as it has no means of determining the cost to the town of making a connection with the said system; but there is no doubt that an outlet into the Metropolitan sewers would be the most satisfactory as regards disposal of the sewage that the town could adopt. The outlet into the ocean, however, is not so far inferior but that the relative cost of the two systems should have much weight in deciding which to adopt.

WESTBOROUGH. The selectmen of Westborough applied to the Board (June 22) for a hearing, under the provisions of the Acts of 1890, chapter 124, "providing for the purchase or taking of land by cities and towns for the purification and disposal of sewage," and requiring the approval of the State Board of Health. Public notice having been given, as required by the same statute, a hearing was held on July 7, at the office of the Board, after which the Board approved the location indicated by the town authorities as follows: —

BOSTON, July 8, 1891.

The State Board of Health has received the petition of the inhabitants of the town of Westborough, made by you under the authority of chapter 124 of the Acts of 1890, entitled, "An Act providing for the purchase or taking of land by cities and towns for the purification and disposal of sewage," asking "that the said town should be authorized to take or purchase a certain tract of land for the purification and disposal of sewage, which tract of land is situated in said Westborough, about one mile northwesterly of the Center village, and being the westerly end of the farm of Charles A. Harrington, and containing 32,067 acres; also another tract of land adjoining said first tract, containing one acre, and being at the north-west corner of the farm of Frank A. Stone; all as shown upon a plan accompanying said petition." In response to this petition, the Board gave a public hearing at its

office in Boston on July 7, 1891, after due notice of said hearing by publication in the "Westborough Chronotype," the "Northborough Enterprise," the "Northborough Farmer" and the "Hudson Enterprise."

The Board, having given the hearing required by law, and having caused an examination of the premises to be made, herewith approves the purchase or taking of the premises described in said petition, and indicated upon the plan which accompanied it.

The following communication was also sent upon the same date: —

BOSTON, July 8, 1891.

We would respectfully call your attention to the fact that the successful disposal of sewage upon the land, the purchase or taking of which has been approved by this Board in another communication of the same date with this letter, depends largely upon the proper preparation of the fields for filtration. When the plans, showing the method of preparing these fields for sewage filtration, are completed, the Board is of the opinion that they should be submitted to the Board for its advice, under the provisions of chapter 375 of the Acts of 1888.

WELLESLEY COLLEGE. The trustees of Wellesley College applied to the Board (September 17) for its advice as to the propriety of changing the method of disposing of the sewage of the college buildings, and as to the best method to be adopted, should a change be made. The Board replied as follows: —

BOSTON, Oct. 6, 1891.

We find that two methods of sewage disposal are now in use.

In the first method the sewage is conducted to filtering houses, each divided into several compartments, and is there passed through artificial filters of peat and gravel. This method is used for disposing of the sewage of the main building, Stone Hall, and the Norumbega and Freeman Cottages.

In the second method the sewage is distributed beneath the surface of the ground by a series of pipes, and permitted to filter away through the natural ground. This method is used to dispose of the sewage of the Wood and Simpson cottages.

The first method is unsatisfactory, both as regards the unsanitary character of the filtering houses and the impurity of the effluent; and should be abolished.

The second method appears to be very satisfactory, as we understand that there are no offensive odors in the vicinity of the

filtering areas; and, while the effluent cannot be seen, there is little doubt, judging from the experience of other places, that the sewage is well purified before reaching the lake.

The essential feature in purifying sewage by filtration is to bring the sewage for a sufficient time in close contact with the oxygen of the air and organisms contained in the ground. This is accomplished where sewage is filtered slowly and intermittently through porous ground, and each grain of sand or gravel is coated with a thin film of sewage in contact with the air contained in the interstices of such porous material; but it cannot be accomplished at the present filtering houses, both because the peat readily becomes saturated with water to the exclusion of air, and because the quantity of sewage to be filtered is so large in proportion to the filtering area that any kind of filtering material used in these tanks would be overtaxed.

The extent of filtering area required for the proper disposal of the sewage is too large to make it advisable to provide it by enlarging the filtering houses; and, as the upland all over the college grounds is, in its natural state, of excellent quality for filtration, the Board advises the adoption of a system of intermittent filtration through the natural ground.

In the absence of exact surveys and levels, the further advice of the Board as to the manner of disposing of the sewage of each building according to this method must necessarily be general in its character.

The sewage of the main building and Norumbega and Freeman cottages could be collected in the valley into which the sewage now runs, and pumped to the level upland beyond the valley in the north-westerly portion of the grounds. Upon this land it could be satisfactorily disposed of by distributing it upon a suitably prepared surface, or by distributing it beneath the surface by means of a system of pipes. It will not, however, be advisable to resort to pumping if it can be avoided, and it is probable that the sewage can be properly disposed of by gravity.

The best place for disposing of the sewage, which now flows to the filtering house west of the Norumbega cottage, appears to be on the side hill on the north-westerly side of the valley, extending from a point nearly opposite the filtering house south-westerly to the wooded land, or, if necessary, through the wooded land to the large gravel pit.

To carry the sewage across the valley, and cause it to rise far enough up the side hill to command the required area, it would be necessary, in order to withstand the pressure, to make the pipe extending across the valley of iron, and to replace with iron pipe

the lower portions of the sewers now laid with ordinary sewer pipe. This iron pipe would remain full of sewage most of the time, and deposits would tend to gather in it. This tendency, however, could be overcome by creating a high velocity through the pipe by means of an automatic flush tank; and, if the pipe is carried across the valley at a relatively high level on the ridge near the ice house, it would be feasible to cause a free flow through it whenever the sewage was disposed of upon the portions of the side hill lower than the lowest part of the pipe. It is hardly clear, from a mere inspection of the premises, whether the sewage from the laundry, kitchen sinks and a few water-closets at the westerly end of the main building can be carried across the valley at the same place as the other sewage or not. If it should be found impracticable to do this, the sewage could be carried across the valley to the gravel pit before mentioned, or to land up towards the paint mills, and there disposed of upon a prepared area. There is also a little doubt as to whether it would be advisable to carry the sewage from the Freeman cottage across the valley, or to some other land in the vicinity of the cottage.

In all cases the land chosen for sewage disposal should not be low or wet, but should be porous, sandy or gravelly land, having its surface not less than six feet above the level of the water in the ground. For disposing of the sewage upon the side hill or gravel pit before mentioned, or upon any land in the vicinity of the buildings, the plan of subsurface disposal by means of pipes should be adopted.

The sewage of Stone Hall can be disposed of upon land in its vicinity. It now seems probable that it will be best to carry the sewage in the direction of the barn, and dispose of it upon the side hill. If this is not feasible, the flat land north of Stone Hall, or a portion of the lawn fronting on Washington Street, should be considered.

The disposal areas should be large enough to provide one hundred square feet of land for each person in the buildings sewered. A somewhat smaller amount of land will answer, if this amount cannot be obtained; but it is advisable to provide the amount stated, where practicable.

In conclusion, it may be said that, to insure success in the disposal of the sewage of your buildings, it is necessary to have the work skilfully designed and proportioned by some competent engineer.

The State Board will give further advice upon this subject, if you so desire, when you have further information to present as to what is found by surveys to be feasible.

MASSACHUSETTS HOSPITAL FOR DIPSOMANIACS AND INEBRIATES. The trustees of this institution, a new public institution located in the town of Foxborough, applied to the Board (October 8) for its advice as to the best mode of disposing of its sewage. The Board replied as follows: —

BOSTON, Dec. 2, 1891.

By this plan it is proposed to collect the sewage from all the buildings at a collecting well back of the laundry, and from this well to build a main sewer to about four acres of low land situated about eight hundred feet back of the laundry; this area to be underdrained to as low a level as possible, by means of pipes discharging into a mill pond below the Neponset reservoir; the surface of the area to be graded and divided into beds, so as to facilitate the uniform distribution of the sewage turned upon them from a carrier which extends nearly around the disposal area; and the distribution of the sewage to be further facilitated by an automatic flush tank, which will discharge the sewage from time to time at a rapid rate, instead of permitting it to trickle over the land.

The proposed plan would probably give satisfactory results if it were feasible to reduce the water level by underdrainage to a sufficient depth below the surface of the ground; but, from the contours shown upon the plan and figures presented by your engineer, it does not appear that this can be done. To raise the surface of the ground to a sufficient height above the ground water would be very expensive.

The Board, therefore, does not advise the adoption of the plan submitted, believing that the application of sewage to such low land would not only insufficiently purify it, but would be liable to cause a nuisance in the vicinity of the disposal area. As a substitute for the plan of sewage disposal presented, the Board suggests that the sewage be filtered intermittently upon an area of one acre of sandy land, having its surface not less than six feet above the present level of the water in the ditch which runs through the low land. To bring the sewage to an area at this height without pumping is somewhat difficult; but it seems probable that it can be done by collecting the sewage from the higher buildings in a flush tank placed not far from the westerly end of the laundry, and by building a sewer extending from this flush tank to the disposal area. If possible, the water from the laundry, and the sewage from other parts of the same building, should be discharged into the flush tank or into the sewers above it; but, if this is not feasible, they might be discharged into the sewer below the

the lower portions of the sewers now laid with ordinary sewer pipe. This iron pipe would remain full of sewage most of the time, and deposits would tend to gather in it. This tendency, however, could be overcome by creating a high velocity through the pipe by means of an automatic flush tank; and, if the pipe is carried across the valley at a relatively high level on the ridge near the ice house, it would be feasible to cause a free flow through it whenever the sewage was disposed of upon the portions of the side hill lower than the lowest part of the pipe. It is hardly clear, from a mere inspection of the premises, whether the sewage from the laundry, kitchen sinks and a few water-closets at the westerly end of the main building can be carried across the valley at the same place as the other sewage or not. If it should be found impracticable to do this, the sewage could be carried across the valley to the gravel pit before mentioned, or to land up towards the paint mills, and there disposed of upon a prepared area. There is also a little doubt as to whether it would be advisable to carry the sewage from the Freeman cottage across the valley, or to some other land in the vicinity of the cottage.

In all cases the land chosen for sewage disposal should not be low or wet, but should be porous, sandy or gravelly land, having its surface not less than six feet above the level of the water in the ground. For disposing of the sewage upon the side hill or gravel pit before mentioned, or upon any land in the vicinity of the buildings, the plan of subsurface disposal by means of pipes should be adopted.

The sewage of Stone Hall can be disposed of upon land in its vicinity. It now seems probable that it will be best to carry the sewage in the direction of the barn, and dispose of it upon the side hill. If this is not feasible, the flat land north of Stone Hall, or a portion of the lawn fronting on Washington Street, should be considered.

The disposal areas should be large enough to provide one hundred square feet of land for each person in the buildings sewered. A somewhat smaller amount of land will answer, if this amount cannot be obtained; but it is advisable to provide the amount stated, where practicable.

In conclusion, it may be said that, to insure success in the disposal of the sewage of your buildings, it is necessary to have the work skilfully designed and proportioned by some competent engineer.

The State Board will give further advice upon this subject, if you so desire, when you have further information to present as to what is found by surveys to be feasible.

MASSACHUSETTS HOSPITAL FOR DIPSOMANIACS AND INEBRIATES. The trustees of this institution, a new public institution located in the town of Foxborough, applied to the Board (October 8) for its advice as to the best mode of disposing of its sewage. The Board replied as follows:—

BOSTON, Dec. 2, 1891.

By this plan it is proposed to collect the sewage from all the buildings at a collecting well back of the laundry, and from this well to build a main sewer to about four acres of low land situated about eight hundred feet back of the laundry; this area to be underdrained to as low a level as possible, by means of pipes discharging into a mill pond below the Neponset reservoir; the surface of the area to be graded and divided into beds, so as to facilitate the uniform distribution of the sewage turned upon them from a carrier which extends nearly around the disposal area; and the distribution of the sewage to be further facilitated by an automatic flush tank, which will discharge the sewage from time to time at a rapid rate, instead of permitting it to trickle over the land.

The proposed plan would probably give satisfactory results if it were feasible to reduce the water level by underdrainage to a sufficient depth below the surface of the ground; but, from the contours shown upon the plan and figures presented by your engineer, it does not appear that this can be done. To raise the surface of the ground to a sufficient height above the ground water would be very expensive.

The Board, therefore, does not advise the adoption of the plan submitted, believing that the application of sewage to such low land would not only insufficiently purify it, but would be liable to cause a nuisance in the vicinity of the disposal area. As a substitute for the plan of sewage disposal presented, the Board suggests that the sewage be filtered intermittently upon an area of one acre of sandy land, having its surface not less than six feet above the present level of the water in the ditch which runs through the low land. To bring the sewage to an area at this height without pumping is somewhat difficult; but it seems probable that it can be done by collecting the sewage from the higher buildings in a flush tank placed not far from the westerly end of the laundry, and by building a sewer extending from this flush tank to the disposal area. If possible, the water from the laundry, and the sewage from other parts of the same building, should be discharged into the flush tank or into the sewers above it; but, if this is not feasible, they might be discharged into the sewer below the

tank. Almost any of the sandy land which surrounds the low area will be suitable for the disposal of the sewage, and a location should be selected with reference to the cost of grading, and the distance from present and future buildings. It seems probable, from an inspection of the plan submitted and of the ground, that the best location for a filter bed adjoins the low land on the side toward the buildings, in the vicinity of the flush tank or discharger shown upon your plan.

NANTUCKET. The sewerage committee of Nantucket applied to the Board (October 22) for its advice relative to plans of sewage disposal for that town. Alternative plans were presented, providing for disposal upon land south-east of the town, and for disposal into the sea on the easterly side of the west jetty. The Board, after hearing the committee, replied as follows:—

BOSTON, Dec. 16, 1891.

Both projects, as presented, provide for collecting the sewage in a tank constructed in a cove between the steamboat wharf and the railroad, and for pumping it at this place; but beyond this point the projects are different. One provides for pumping the sewage through a pipe to land north of the Siasconset road, and on both sides of the road leading to Monomoy Heights. At the hearing given members of your committee by the Board, it was proposed to modify this plan by locating the filtration area a little further from the town, and south of the Siasconset road above mentioned. It is proposed to purify the sewage by filtering it through this land.

The second project provides for an iron pipe of the same size as that leading to the filtration area, extending through North Beach Street to near the Cliff Range Beacons, thence along the southeasterly side of the jetty to a point fully half a mile from the shore, and not far from the outer end of the jetty, where the sewage is to be discharged only upon the outgoing tide.

In addition to these plans, you have submitted estimates of the cost of the portion of the works at and beyond the pumping station, with the view of showing the comparative costs of the two projects, as follows: —

Cost of the works from the pumping station to the disposal area, not including land damages or the preparation of the land for filtration, ...	$23,000
Cost of works from the pumping station to the outlet near the outer end of the jetty, not including land damages, . . .	30,943

The difference in the estimates is $7,943 in favor of disposal upon land.

With regard to the first plan, which provides for the disposal of the sewage upon land, it may be said that the land selected is of suitable quality for filtering the sewage. If the land is properly prepared for distributing the sewage over it, and proper attention is given to the management of the works, so as to insure the proper distribution of the sewage, and large deposits of decomposing matter are not allowed to accumulate in the storage tank or force-main, there is no reason to doubt that the sewage can be purified by filtration without causing any offence in the vicinity of the disposal area. As a greater precaution, however, the Board favor the suggestion to your committee that the sewage be carried a little farther, to land south of the Siasconset road, which seems to be of equally good quality for the purpose.

With regard to the jetty plan, the Board believes it would be advisable to limit the discharge of sewage to the first two or three hours of the outgoing tide, and to screen the sewage at the storage tank, and remove from it all coarse substances which might float about for a considerable time and possibly reach the shores, and also all lumps of grease which may accumulate in the storage tank. It would not advise, however, the removal of any other foul matters which might during their removal cause an offensive odor in the vicinity of the tank.

With these precautions taken, the jetty outlet would, in the judgment of the Board, dispose of the sewage in an entirely satisfactory manner; because the outlet is a long distance from the shore, and the great quantity of water which passes out by the jetties during every ebb tide insures a sufficient current to carry the sewage so far out to sea that none of it is likely to be found upon any of the beaches.

The figures of comparative cost already given, which show a difference of $7,943 in favor of land disposal, do not show conclusively which plan will involve the greatest ultimate expense. The difference in first cost above given will be reduced when the cost of the land and its preparation is included. The annual expense of operating a land-disposal plan will be considerably greater than the other, both on account of the labor required to distribute the sewage over the land, and on account of the greater height to which the sewage must be lifted. The Board would also suggest that it may be feasible to diminish the cost of the jetty plan, and to improve the grades of the sewers in the low land at Brant Point by locating the pumping station near the Cliff Range Beacons or the shore end of the jetty.

The Board can at present advise that both methods of disposal suggested, with the slight modifications mentioned, will efficiently dispose of the sewage. The choice as to which should be adopted should depend to a considerable extent upon the relative cost of the two systems, taking into account all the items of first cost, including land damages, and also the annual running expenses and maintenance. The choice may also be governed by minor considerations of local nature, and by the possibility of any interference with the attractions of the town as a summer resort.

EASTHAMPTON. A committee of the town of Easthampton applied to the Board (November 14) for its advice relative to a proposed system of sewerage having its outlet into a brook below the town and a short distance from the Manhan River. An additional request was made for advice as to the propriety of building a part of the system with temporary outlets into certain mill-ponds, and into the Manhan River opposite the town. The Board replied as follows: —

BOSTON, Jan. 6, 1892.

This plan consists of a system of pipe sewers which will deliver their flow into a main pipe laid through the Williston Mills Pond. This main pipe is to pass around the easterly end of the dam and discharge into the brook below the dam, at the culvert under the Mt. Tom Branch Railroad, not far from the Manhan River. It is further understood that the system is to take sewage only, and not the street or other surface water.

The Board is of opinion that the sewage can, for the present, be discharged into the Manhan River below the town, without causing any serious trouble. The discharge into the brook at the railroad culvert, a short distance from the river, as proposed, is less satisfactory; but, as any trouble which may be occasioned by such discharge can easily be obviated by extending the main sewer to the river, the Board is of opinion that an outlet at this place is temporarily permissible. At some time in the future it is probable that the sewage will have to be purified before being discharged into the Manhan River, or else entirely removed from this stream; and, with this probability in view, the Board commends the adoption of a system of sewers for sewage only, as with a system of this kind the sewage can be treated when necessary with less expense than where the volume flowing is increased by the admission of surface or other water which is not seriously polluted and could go into the nearest streams.

With regard to the proposition to dispose of the sewage of a

portion of the town for the present into the Nashawannuck and Williston Mills ponds, and into the Manhan River at points opposite the town, the Board does not advise the discharge of sewage into the mill ponds, but is of opinion that the temporary discharge of the sewage into the Manhan River opposite the town is permissible, if it should be found for the interests of the town to provide such temporary outlets. The construction of a permanent outlet at a point just below the dam across the river, for a short sewer in Manhan Street, seems to be unobjectionable.

Pollution of Streams.

The following is the substance of the action of the Board relative to the subject of the pollution of inland streams: —

The Fowl Meadows on the Neponset River. A complaint was received from C. Sumner of Canton (July 20), concerning "a certain tract of land of about six thousand acres, situated on either side of the Neponset River, and adjoining and lying between the towns of Canton, Walpole, Sharon, Hyde Park, Norwood, Dedham and Roxbury in the city of Boston. For the last ten or twelve years the said meadows have been kept in such a state from back water, owing, it is said, to several manufacturing concerns at Hyde Park and below having their dams higher than they should be, that the stench arising therefrom is at times most unbearable, and is the direct cause of much sickness, of malarial and kindred diseases, which were said to be unknown in this locality before such state of affairs existed." The applicant also requested that the Board would take such steps "as were within its province, to have the nuisance abated."

The Board replied that "it might properly investigate the question as a possible source of illness, but was not aware that any legislation gave to the Board the power to abate it."

The Board instituted an investigation at once, the results of which will be presented in a subsequent portion of this report.

Alewife Brook. A communication was received from the Board of Health of Medford (Aug. 21, 1891), complaining that the city of Cambridge was "about to widen Ale-

wife Brook to give a larger outlet to the river for the sewage." The Board of Health of Medford protested against such action, and requested the State Board to investigate the matter. To this communication the Board replied as follows: —

BOSTON, Oct. 7, 1891.

The Board finds that practically all of the improvement relates to the portion of the brook above the tide-gates near Broadway. As these tide-gates shut out the water, the amount of water going out through them at each tide, now that the improvement is completed, is the same as formerly; namely, the amount of upland water and sewage accumulating in the brook while the tide gates are closed. After a heavy storm the conditions may be somewhat different, as the storm water, which formerly required more than one low tide to flow out, may go out in a single tide. After due consideration of the subject the Board does not find any ground for thinking that this improvement of the brook will injuriously affect Medford, while, on account of the lowering of the water, it is a manifest advantage to the portions of Cambridge, and of other towns, near the brook.

EXAMINATIONS OF WATER SUPPLIES AND RIVERS.

WATER SUPPLIES.

EXAMINATION OF WATER SUPPLIES.

EXPLANATORY NOTE.

The following tabulation, giving descriptions of water works, and chemical and biological examinations of many sources of water supply in the State, is a continuation of similar tabulations published in two previous reports.

The systematic examination of the water supplies of the State was begun June 1, 1887, and has been continued up to the present time. The results for the two years ending June 1, 1889, may be found in the Special Report of the Board upon the Examination of Water Supplies, 1890, and for the nineteen months from June 1, 1889, to Dec. 31, 1890, in the last [twenty-second] annual report of the Board. The present report contains the results for the year 1891.

The Special Report contained a description of each water supply in the State; to avoid repetition, the last report and the present one contain only descriptions of new works and those which have been materially changed.

An alphabetical arrangement by towns has been adopted, as in previous reports. Sources of water supply are tabulated under the name of the town supplied, other waters under the name of the town in which they are situated. The analyses of water from the larger rivers not used as sources of water supply are given in a subsequent tabulation, headed "Rivers."

The chemical examinations in this report were made in the same manner as heretofore, and are presented in the tables in precisely the same form as last year. Since June 1, 1889, the waters containing suspended matter have been filtered before determining the residue on evaporation. Before that date these determinations were made with the unfiltered water.

A few cases will be noted in the tabulated results in which one or more chemical determinations differ somewhat widely from others in the series. Such a condition of the water might result from floods or other unusual disturbance of a stream, or from carelessness in collection; or an error may have been made in the analysis. In such cases the determination has been underlined, and has not been included in the average.

The color of waters is expressed by numbers, which increase with the amount of color. Water having a color of 1.0 is a decided yellowish-brown when seen in small bulk, as in a tumbler.

In the microscopical examination of the waters there has been a decided advance from time to time in the methods employed for determining quantitatively the number of organisms present. These methods were so far perfected on Nov. 6, 1890, however, that since that date there has been no material modification, and the results given in this report are therefore comparable with

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Sus-pended.	Chlorine.	Nitrates.	Nitrites.
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sira, 7; *Navicula*, 1; *Syn*
lomonas, pr. Miscellan

AG WATER COMPAN

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istance from the dam

the bottom of the rese
rvoir does not fill. It

ASHBURNHAM.

Chemical Examination of Water from Upper Naukeag Pond, Ashburnham.

NOTE. — This pond is not used as a source of public water supply.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
7908	Sept. 9	Sept. 10	Slight.	Slight.	0.00	1.90	0.85	.0000	.0122	.0122	.0000	.09	.0030	.0000	0.0

Odor, none. —— The sample was collected from the pond about four feet beneath the surface. The surface of the water in the pond was about four feet below high-water mark at the time the sample was collected.

Microscopical Examination.

Algæ, *Botrycoccus*, pr.; *Chlorococcus*, 10. Miscellaneous, *Zoöglæa*, 31; *Starch grains*, 1. Total, 42.

WATER SUPPLY OF ATHOL.

Chemical Examination of Water Collected at the Small Reservoir in Phillipston.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
8002	Oct. 3	Oct. 6	Slight.	Cons.	0.70	3.65	1.45	.0006	.0202	.0130	.0072	.06	.0050	.0000	1.1

Odor, vegetable. —— The sample was collected from the brook, because, owing to the dry weather, the reservoir was empty.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 2,046; *Cyclotella*, 1; *Diatoma*, 1; *Navicula*, pr.; *Surirella*, 2; *Synedra*, 2. Cyanophyceæ, *Anabæna*, 14. Algæ, *Closterium*, 1; *Pandorina*, 1; *Sorastrum*, 1. Fungi, *Crenothrix*, 74. Infusoria, *Trachelomonas*, pr. Miscellaneous, *Zoöglæa*, 372. Total, 2,515.

Chemical Examination of Water from the Large Reservoir in Phillipston.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
8003	Oct. 3	Oct. 6	Decided.	Cons.	0.70	4.15	2.55	.0000	.1892	.0566	.1826	.08	.0050	.0000	1.1

Odor, vegetable. —— The sample was collected from the reservoir near the gate-house, at the surface.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 20; *Melosira*, 540. Cyanophyceæ, *Anabæna*, 3,520; *Chroöcoccus*, 20. Miscellaneous, *Zoöglæa*, 1,180. Total, 5,280.

ATHOL.

Chemical Examination of Water from Faucets in Athol, supplied from the Works of the Athol Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8004	Oct. 3	Oct. 6	Distinct, milky.	Slight.	0.35	3.85	1.75	.0058	.0626	.0336	.0290	.08	.0100	.0000	1.1
8240	Nov. 9	Nov. 10	Slight.	Slight.	0.75	4.05	1.80	.0046	.0438	.0294	.0144	.12	.0070	.0001	0.5

Odor, vegetable; No. 8240, unpleasant.——The samples were collected from faucets in the lower portion of the town near the railroad station.

Microscopical Examination.

No. 8004. Diatomaceæ, *Asterionella*, 3. Cyanophyceæ, *Anabæna*, 9. Miscellaneous, *Zoöglœa*, 304. Total, 316.

No. 8240. Diatomaceæ, *Asterionella*, 37; *Cyclotella*, 1; *Diatoma*, 1; *Melosira*, 14; *Synedra*, 35; Cyanophyceæ, *Anabæna*, 12. Algæ, *Chlorococcus*, pr.; *Pediastrum*, pr.; *Scenedesmus*, 2; *Staurastrum*, 10. Fungi, *Crenothrix*, 27. Infusoria, *Dinobryon cases*, 1; *Peridinium*, 1. Vermes, *Anurea*, pr.; *Rotatorian ova*, pr. Miscellaneous, *Zoöglœa*, 140. Total, 281.

Water Supply of the Attleborough Fire District, Attleborough.

A new covered tank, 30 feet in diameter and 125 feet in height, has recently been built, thereby furnishing a greater pressure for fire and other purposes throughout the town, and increasing the storage capacity of the works. The old tank is retained, and kept filled with water directly from the river by an independent pump. A line of pipe has been laid from this tank through the village as far as the railroad station, in order to supply locomotive and other boilers with the river water, which is much softer than the water from the well.

In the latter part of 1891 an investigation was made with reference to obtaining a new water supply * for the fire district, and many samples were collected from tubular test wells and other sources within the limits of the town, the analyses of which are given in the tables which follow.

* The advice of the State Board of Health to the water supply committee of the Attleborough Fire District may be found on page 22 of this report.

ATTLEBOROUGH.

Chemical Examination of Water from the Well of the Attleborough Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exami-nation.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7950	Sept. 18	Sept. 18	V. slight, milky.	Slight.	0.00	11.00	.0020	.0024	1.33	.1400	.0010	3.5
7949	Sept. 18	Sept. 18	None.	Slight.	0.00	13.90	.0000	.0000	1.61	.0600	.0090	5.7

Odor, none. —— Sample No. 7950 was collected from the large well; No. 7949 from a tubular well sunk in the bottom of the large well.

Microscopical Examination.

No. 7950. Fungi, *Crenothrix*, 6. Miscellaneous, *Zoöglœa*, 3. Total, 9.

No. 7949. Diatomaceæ, *Asterionella*, 16; *Cyclotella*, pr.; *Diatoma*, 11; *Tabellaria*, 2. Miscellaneous, *Zoöglœa*, 6. Total, 35.

Chemical Examination of Water from Tubular Test Wells in Attleborough.

Number of Well.	Chemical Number.	Date of Collection.	Date of Exam-ination	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
		1891.											
1	7738	July 30	Aug. 1	V. slight.	Slight, earthy.	0.0	5.10	.0040	.0000	.32	.0100	.0000	1.5
1	7818	Aug. 15	Aug. 15	Slight, clayey.	None.	0.0	4.10	.0054	.0014	.27	.0020	.0000	1.1
1	7951	Sept. 18	Sept. 18	Slight, clayey.	Consid., sand.	0.0	5.90	.0026	.0006	.31	.0070	.0000	1.7
2	7737	July 31	Aug. 1	V. slight.	V. slight.	0.0	5.20	.0084	.0000	.37	.0090	.0000	0.6
3	7819	Aug. 15	Aug. 15	V. slight.	None.	0.0	6.00	.0004	.0014	.32	.0020	.0000	0.9
4	7901	Sept. 3	Sept. 4	V. slight.	None.	0.0	5.20	.0086	.0016	.23	.0070	.0001	1.7
5	7902	Sept. 3	Sept. 4	Distinct, clayey.	Consid., clayey.	0.0	9.90	.0004	.0010	1.13	.3500	.0000	2.7
6	7909	Sept. 9	Sept. 10	Distinct, clayey.	Slight.	0.0	3.20	.0000	.0040	.22	.0250	.0000	0.6
6	7952	Sept. 18	Sept. 18	Distinct, clayey.	Slight, sand.	0.0	3.80	.0000	.0000	.23	.0400	.0000	0.6
7	8001	Oct. 3	Oct. 4	Distinct.	Slight, sand.	0.0	7.50	.0012	.0000	.29	.0030	.0000	1.8
7	8124	Oct. 15	Oct. 16	Slight, clayey.	Slight.	0.0	5.80	.0002	.0000	-	.0030	.0000	-
8	8172	Oct. 28	Oct. 29	Distinct, clayey.	Consid., sand.	0.0	4.50	.0014	.0014	.24	.0750	.0000	1.2
8	8173	Oct. 28	Oct. 29	Decided, clayey.	Heavy, sand.	0.0	5.50	.0002	.0006	.24	.0800	.0000	1.2
9	8270	Nov. 20	Nov. 21	None.	None.	0.0	3.40	.0000	.0012	.28	.0120	.0000	1.4

ATTLEBOROUGH.

The first eight wells are located in the Bungay Valley, in or near the Bungay Swamp. The ninth well is located near the Seven Mile River.

Of the wells in the Bungay Valley, Nos. 1, 2 and 3 are located in the Bungay Swamp, near its southerly edge between the Providence Division of the Old Colony Railroad and the Bungay River, and are nearer the town than any other of the wells. No. 1 is about 400 and No. 2 is 720 feet from the railroad. No. 3 is between No. 1 and No. 2. Nos. 1 and 2 were driven in 1886, and all the other wells at the time the investigations were made.

No. 4 is east of the railroad, and a little farther from the town than the first three. It is in a small swamp a short distance from the main one.

No. 5 is on the easterly side of the swamp, west of the railroad, and much farther from the town than the first four.

No. 6 is at the westerly edge of the swamp, more than a mile from the town.

No. 7 is in the swamp, 860 feet east of No. 6.

No. 8 is also in the swamp, 1,200 feet south of No. 6.

No. 9 is near the Seven Mile River, just above the point where it flows into Orr's Millpond.

The water from several of these test wells in and near the Bungay Swamp is characterized by a disagreeable odor, resembling sulphuretted hydrogen (probably the odor is due mainly to the presence of carburetted hydrogen), and by the presence of iron in solution in considerable quantity. The water is clear and colorless when pumped, but quickly becomes turbid and reddish colored, by reason of the precipitation of oxide of iron, when the water is exposed to the air. The odor of the water gradually disappears on exposure, and in some cases may have escaped detection when the water was examined the day after collection.

The water from the test wells Nos. 1, 2 and 3 on the southerly edge of the swamp became turbid on standing, and a decided odor was noticed in the samples numbered 7818, 7951 and 7819. In No. 7951 the iron was determined quantitatively, and found to be 0.665 parts per 100,000 of metallic iron, equivalent to 0.38 of a grain per gallon. The amount of pumping done before collecting these samples was as follows: No. 7818, five hours the previous afternoon and two hours in the morning before collecting the sample; No. 7951, five minutes; No. 7737, six hours; No. 7819, five hours' pumping the previous afternoon and two hours in the morning before collecting the sample.

The sample from Well No. 4, which is just east of the railroad and in a small swamp separated by some gravelly land from the main swamp, had also a decided odor and contained considerable iron. This sample was collected after eight hours' pumping.

In the water of Well No. 5, which was sunk in hard ground a short distance away from the swamp, and which by reason of its location was considerably polluted by drainage from a farm-house, no odor or precipitation of iron was noticed.

In the water of Well No. 6, on the west side of the swamp, no odor was noticed, and the amount of iron, which was determined quantitatively, was quite insignificant, being only 0.022 parts per 100,000. The first sample from this well was collected after eight hours' pumping and the second sample after pumping only a short time.

Well No. 7, in the swamp 860 feet east of Well No. 6, gave water which contained considerable iron, which precipitated out on standing, but no odor was noticed. The amount of iron in No. 8124 was 0.370 parts per 100,000. No. 8124 was collected after four hours' pumping.

Of the samples from Well No. 8, also situated in the swamp, 1,200 feet south of Well No. 6, there was a distinct odor in No. 8173, which contained 0.280 parts of iron. Sample No. 8172 had no odor and contained only 0.120 parts of iron. No. 8172 was collected when the well had been driven ten feet below the surface of the ground, after one and one-half hours' pumping; and No. 8173 from a depth of twenty feet below the surface of the ground, after one-half hour's pumping.

Well No. 9, near the Seven Mile River, gave water without odor and with only 0.050 parts of iron per 100,000.

Microscopical Examination of Water from Tubular Test Wells in Attleborough.

[Number of organisms per cubic centimeter.]

	1891.											
	Aug.	Aug.	Sept.	Aug.	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Nov.
Date of examination,	1	17	19	1	17	5	5	10	19	6	16	21
Number of sample,	7738	7818	7951	7737	7819	7901	7902	7909	7952	8001	8124	8270
Number of well,	1	1	1	2	3	4	5	6	6	7	7	9
Zoöglœa,	2	0	1770	3	1012	184	0	26	0	882	2	0

ATTLEBOROUGH.

Chemical Examination of Water from Streams in Attleborough, made during an Investigation with reference to obtaining a New Water Supply for the Attleborough Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8269	Nov. 20	Nov. 21	V. slight.	V. slight.	0.50	4.15	1.90	.0000	.0154	.0128	.0026	.46	.0030	.0000	1.1
8278	Nov. 25	Nov. 25	V. slight.	V. slight.	0.60	3.95	1.35	-	-	-	-	.47	-	-	-
8277	Nov. 25	Nov. 25	V. slight.	V. slight.	0.30	4.00	1.20	.0006	.0088	.0084	.0004	.36	.0070	.0000	1.4

Odor of each, faintly vegetable.——Nos. 8269 and 8278 were collected from the Seven Mile River just above Orr's Pond near South Attleborough. No. 8277 was collected from Four Mile Brook, at first road crossing above Orr's Pond.

Microscopical Examination.

No. 8269. Diatomaceæ, *Diatoma*, pr. Miscellaneous, *Zoöglœa*, pr.

No. 8277. Diatomaceæ, *Diatoma*, 2; *Grammatophora*, 4; *Meridion*, 1; *Synedra*, 4. Fungi, *Crenothrix*, 45. Miscellaneous, *Zoöglœa*, 13. Total, 69.

WATER SUPPLY OF AVON.

Chemical Examination of Water from the Well of the Avon Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8244	Nov. 9	Nov. 11	None.	None.	0.00	3.80	.0014	.0000	.34	.0500	.0000	0.8

Odor, none.——The sample was collected from a faucet at the pumping station, while pumping.

Microscopical Examination.

No organisms.

WATER SUPPLY OF BELMONT.

(See *Watertown*.)

WATER SUPPLY OF BEVERLY.

(See *Salem*.)

WATER SUPPLY OF BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6853	Jan. 1	Jan. 2	None.	V. slight.	1.10	4.80	1.45	.0012	.0248	.0208	.0040	.29	.0280	.0001	1.7
6962	Feb. 2	Feb. 3	None.	V. slight.	0.80	3.10	1.00	.0010	.0160	.0146	.0014	.12	.0100	.0001	0.9
7069	Mar. 2	Mar. 3	V. slight.	V. slight.	1.20	3.50	1.70	.0006	.0214	.0190	.0024	.17	.0100	.0002	1.1
7160	Apr. 3	Apr. 4	V. slight.	Heavy.	0.65	3.00	1.40	.0000	.0142	.0116	.0026	.16	.0030	.0001	0.8
7272	May 4	May 5	V. slight.	Slight.	1.30	4.00	1.95	.0002	.0294	.0226	.0068	.21	.0050	.0000	1.1
7367	June 1	June 2	Distinct.	Cons.	1.40	4.20	1.75	.0016	.0328	.0290	.0038	.20	.0040	.0000	1.3
7512	July 1	July 2	V. slight.	V. slight.	1.90	5.50	2.90	.0004	.0380	.0334	.0046	.19	.0020	.0001	1.1
7740	Aug. 3	Aug. 4	None.	V. slight.	1.00	4.65	2.00	.0000	.0222	.0210	.0012	.19	.0050	.0000	1.1
7871	Sept. 1	Sept. 2	V. slight.	Slight.	1.60	6.40	3.45	.0018	.0374	.0310	.0064	.25	.0020	.0002	1.3
7987	Oct. 1	Oct. 2	V. slight.	Cons.	1.00	5.70	2.75	.0004	.0348	.0320	.0028	.29	.0030	.0000	1.4
8184	Nov. 2	Nov. 3	V. slight.	V. slight.	1.70	6.65	3.55	.0012	.0386	.0360	.0026	.31	.0070	.0000	1.7
8287	Dec. 2	Dec. 2	V. slight.	V. slight.	1.90	7.00	3.65	.0022	.0462	.0432	.0030	.34	.0250	.0000	1.9
Av.	....	....	....	....	1.30	4.87	2.30	.0009	.0297	.0262	.0035	.23	.0087	.0001	1.3

Odor, distinctly vegetable, sometimes none; when heated, generally distinctly vegetable, sometimes strongly vegetable. —— The samples were collected from the brook where it enters the reservoir.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, .	3	4	5	6	12	2	2	4	2	2	3	3
Number of sample, .	6853	6962	7069	7160	7272	7367	7512	7740	7871	7987	8184	8287
PLANTS.												
Diatomaceæ, . .	1	9	17	454	63	50	1	1	5	2	37	7
Achnanthidium, .	0	0	0	0	0	0	0	0	0	0	26	0
Diatoma, . . .	0	3	4	299	48	18	1	0	2	0	1	0
Melosira, . . .	0	0	0	6	0	0	0	0	1	0	0	0
Meridion, . . .	pr.	1	3	1	1	1	0	0	pr.	0	0	0
Navicula, . . .	0	pr.	0	1	1	4	0	pr.	0	0	1	0
Nitzschia, . . .	1	3	2	0	0	2	0	0	0	0	2	0
Synedra, . . .	0	2	6	140	8	11	0	1	2	0	1	7
Tabellaria, . .	0	0	2	7	5	14	0	0	0	2	6	0

BOSTON.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ. Chlorococcus, .	0	3	0	0	0	2	0	1	0	0	0	0
Fungi. Crenothrix, .	0	0	0	16	60	42	pr.	5	28	40	pr.	0
ANIMALS.												
Infusoria, . . .	1	pr.	0	pr.	1	3	0	0	2	pr.	0	0
Dinobryon, . .	0	0	0	0	1	3	0	0	0	0	0	0
Monas, . . .	0	0	0	pr.	0	0	0	0	1	pr.	0	0
Peridinium, . .	1	pr.	0	0	0	0	0	0	1	0	0	0
Crustacea, . .	0	0	0	0	pr.	0	0	0	0	0	0	0
Bosmina, . . .	0	0	0	0	pr.	0	0	0	0	0	0	0
Cyclops, . . .	0	0	0	0	pr.	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	0	25	64	0	210	55	6	3	64	34	2	0
TOTAL, . . .	2	37	81	470	334	152	7	10	97	76	39	7

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected one foot beneath the surface.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6854	Jan. 1	Jan. 2	V. slight.	V. slight.	0.80	4.30	1.90	.0028	.0260	.0220	.0040	.26	.0200	.0001	1.7
6963	Feb. 2	Feb. 3	V. slight.	V. slight.	0.90	3.35	1.15	.0010	.0188	.0162	.0026	.17	.0120	.0001	0.9
7070	Mar. 2	Mar. 3	V. slight.	V. slight.	0.40	3.35	1.25	.0002	.0116	.0086	.0030	.11	.0070	.0002	0.6
7161	Apr. 3	Apr. 4	V. slight.	V. slight.	0.65	3.60	1.60	.0000	.0134	.0118	.0016	.17	.0050	.0001	0.8
7273	May 4	May 5	V. slight.	V. slight.	0.65	3.30	1.75	.0002	.0180	.0162	.0018	.18	.0060	.0000	0.6
7368	June 1	June 2	Slight.	Slight.	0.60	2.80	1.30	.0008	.0218	.0186	.0032	.18	.0030	.0001	0.8
7513	July 1	July 2	V. slight.	V. slight.	0.60	2.85	1.40	.0004	.0190	.0148	.0042	.16	.0020	.0001	0.8
7741	Aug. 3	Aug. 4	Slight.	V. slight.	0.40	3.15	1.60	.0000	.0214	.0174	.0040	.21	.0030	.0000	0.6
7872	Sept. 1	Sept. 2	V. slight.	Slight.	0.30	2.95	1.75	.0002	.0204	.0156	.0048	.20	.0020	.0001	0.9
7988	Oct. 1	Oct. 2	Slight.	Slight.	0.35	3.25	1.85	.0000	.0178	.0146	.0032	.23	.0070	.0000	0.9
8185	Nov. 2	Nov. 3	Distinct.	Slight.	0.30	3.00	1.90	.0004	.0186	.0164	.0022	.24	.0050	.0000	0.9
8288	Dec. 2	Dec. 2	V. slight.	V. slight.	0.40	3.00	1.20	.0008	.0182	.0152	.0030	.25	.0020	.0002	0.8
Av.	....	....	....	....	0.53	3.24	1.55	.0006	.0187	.0156	.0031	.20	.0062	.0001	0.9

Odor, generally very faintly vegetable or none. —— The samples were collected from the reservoir near the gate-house, at a depth of one foot beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

Microscopical Examination of Water from Reservoir No. 4, in Ashland, collected one foot beneath the surface.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	4	5	6	12	2	2	4	2	2	3	3
Number of sample,	6854	6963	7070	7161	7273	7368	7513	7741	7872	7988	8185	8288
PLANTS.												
Diatomaceæ,	**46**	**3**	**1**	**6**	**83**	**104**	**89**	**561**	**265**	**106**	**75**	**183**
Cyclotella,	0	0	0	0	56	0	0	557	242	104	71	160
Diatoma,	4	0	0	0	1	0	0	0	0	0	1	0
Meridion,	4	0	pr.	1	1	0	0	0	0	0	0	0
Navicula,	4	1	0	0	1	0	0	0	pr.	1	1	pr.
Nitzschia,	18	0	0	0	0	0	0	0	0	0	0	0
Stephanodiscus,	1	1	0	pr.	7	90	89	3	0	0	pr.	0
Synedra,	10	1	1	1	15	14	0	0	23	0	2	22
Tabellaria,	5	0	0	4	2	0	0	1	0	1	pr.	1
Cyanophyceæ. Chroöcoccus,	**0**	**0**	**0**	**0**	**7**	**116**	**0**	**0**	**0**	**0**	**0**	**0**
Algæ,	**0**	**0**	**6**	**0**	**2**	**127**	**1**	**33**	**51**	**0**	**14**	**23**
Chlorococcus,	0	0	6	0	2	76	1	4	0	0	6	3
Conferva,	0	0	0	0	0	0	0	0	40	0	0	0
Raphidium,	0	0	0	0	0	23	0	29	11	0	8	10
Sorastrum,	0	0	0	0	0	28	0	0	0	0	0	0
Staurogenia,	0	0	0	0	0	0	0	0	0	0	0	10
Fungi. Crenothrix,	**0**	pr.	**0**	**2**	**4**	**0**	**0**	**0**	**2**	pr.	**1**	**0**
ANIMALS.												
Infusoria,	**1**	pr.	**10**	**23**	**0**	**5**	pr.	pr.	**1**	**0**	**3**	pr.
Dinobryon,	0	0	3	22	0	0	0	0	0	0	1	pr.
Monas,	0	0	0	0	0	0	0	pr.	1	0	1	0
Peridinium,	1	pr.	7	1	0	0	0	0	pr.	0	pr.	0
Trachelomonas,	pr.	pr.	pr.	pr.	0	0	pr.	0	0	0	1	pr.
Vorticella,	0	0	0	0	0	5	0	0	0	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	pr.	pr.	**0**	**0**	**0**	**0**	**0**	**0**
Bosmina,	0	0	0	0	0	pr.	0	0	0	0	0	0
Cyclops,	0	0	0	0	pr.	0	0	0	0	0	0	0
Daphnia,	0	0	0	0	0	pr.	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**15**	**136**	**13**	**23**	**288**	**4**	pr.	**7**	**224**	**72**	**34**	**46**
TOTAL,	62	139	30	54	384	356	90	601	543	178	127	252

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected twenty feet beneath the surface.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6855	Jan. 1	Jan. 2	V. slight.	V. slight.	0.90	3.90	1.65	.0020	.0232	.0210	.0022	.25	.0200	.0001	1.7
6964	Feb. 2	Feb. 3	V. slight.	V. slight.	0.90	3.95	1.65	.0024	.0202	.0176	.0026	.19	.0100	.0001	1.1
7071	Mar. 2	Mar. 3	V. slight.	V. slight.	0.75	3.90	1.80	.0008	.0152	.0132	.0020	.19	.0110	.0002	0.9
7162	Apr. 3	Apr. 4	V. slight.	V. slight.	0.65	3.30	1.40	.0006	.0140	.0128	.0012	.16	.0050	.0001	0.9
7274	May 4	May 5	V. slight.	V. slight	0.60	3.15	1.55	.0004	.0172	.0150	.0022	.18	.0060	.0000	0.7
Av.	....	....	....	....	0.76	3.64	1.61	.0012	.0179	.0159	.0020	.19	.0104	.0001	1.1

Odor, generally very faintly vegetable or none. —— The samples were collected from the reservoir near the gate-house, at a depth of twenty feet beneath the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	March.	April.	May.
Day of examination,	3	4	5	6	12
Number of sample,	6855	6964	7071	7162	7274
PLANTS.					
Diatomaceæ,	**9**	**32**	**10**	**5**	**39**
Cyclotella,	0	0	0	0	5
Diatoma,	0	0	2	0	4
Meridion,	0	0	4	3	0
Stephanodiscus,	9	28	pr.	0	6
Synedra,	0	4	4	2	24
Algæ. Zoöspores,	**0**	**0**	**0**	**2**	**0**
Fungi. Crenothrix,	**pr.**	**pr.**	**pr.**	**3**	**3**
ANIMALS.					
Infusoria,	**0**	**0**	**pr.**	**14**	**0**
Dinobryon,	0	0	0	13	0
Peridinium,	0	0	pr.	pr.	0
Trachelomonas,	0	0	0	1	0
Vermes. Anuræa,	**pr.**	**0**	**0**	**pr.**	**0**
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**pr.**
Miscellaneous, Zoöglœa,	**22**	**86**	**304**	**11**	**164**
TOTAL,	31	118	314	35	206

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected near the bottom.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6856	Jan. 1	Jan. 2	V.slight.	V.slight.	1.00	3.95	1.40	.0034	.0236	.0210	.0026	.25	.0250	.0001	1.7
6965	Feb. 2	Feb. 3	None.	V.slight.	0.80	4.05	1.40	.0038	.0198	.0176	.0022	.19	.0120	.0001	1.4
7072	Mar. 2	Mar. 3	V.slight.	V.slight.	0.80	3.20	1.40	.0018	.0178	.0144	.0034	.27	.0110	.0002	1.4
7163	Apr. 3	Apr. 4	V.slight.	V.slight.	0.60	3.45	1.65	.0010	.0144	.0130	.0014	.18	.0050	.0001	0.9
7275	May 4	May 5	V.slight.	V.slight.	0.55	4.20	1.65	.0002	.0162	.0140	.0022	.18	.0070	.0000	0.9
Av.	....	....	....	....	0.75	3.77	1.50	.0020	.0184	.0160	.0024	.21	.0120	.0001	1.3

Odor, generally very faintly vegetable or none. —— The samples were collected from the reservoir just above the bottom, near the gate-house. When the reservoir is full the sample is collected forty feet beneath the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	March.	April.	May.
Day of examination,	3	4	5	6	12
Number of sample,	6856	6965	7072	7163	7275
PLANTS.					
Diatomaceæ,	22	8	5	2	5
Diatoma,	0	0	0	1	4
Stephanodiscus,	13	8	5	0	pr.
Synedra,	9	0	pr.	1	1
Cyanophyceæ. Chroöcoccus,	8	0	0	0	0
Fungi. Crenothrix,	0	0	0	2	5
ANIMALS.					
Infusoria,	0	0	0	7	0
Dinobryon,	0	0	0	7	0
Peridinium,	0	0	0	pr.	pr.
Miscellaneous, Zoöglœa,	20	44	162	5	134
TOTAL,	50	52	167	16	144

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Sudbury River at the Upper End of Reservoir No. 2, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6857	Jan. 1	Jan. 2	None.	V. slight.	1.10	4.70	1.70	.0016	.0226	.0196	.0030	.31	.0280	.0001	1.6
6955	Feb. 2	Feb. 3	Slight.	Slight.	0.70	3.30	1.15	.0010	.0186	.0162	.0024	.16	.0150	.0001	1.3
7073	Mar. 2	Mar. 3	V. slight.	V. slight.	0.70	2.95	1.20	.0004	.0222	.0196	.0026	.22	.0070	.0002	0.6
7164	Apr. 3	Apr. 4	V. slight.	Cons.	0.40	3.30	1.55	.0006	.0140	.0106	.0034	.19	.0050	.0001	0.8
7263	May 4	May 5	V. slight.	Cons.	0.80	3.65	1.55	.0006	.0252	.0228	.0024	.22	.0090	.0000	1.1
7369	June 1	June 2	Distinct.	Cons.	0.90	4.35	1.55	.0018	.0328	.0266	.0062	.23	.0100	.0001	1.3
7529	July 2	July 3	V. slight.	Cons.	1.30	5.15	2.80	.0004	.0398	.0320	.0078	.19	.0070	.0001	0.9
7742	Aug. 3	Aug. 4	Slight.	Cons.	0.75	4.05	2.00	.0000	.0288	.0238	.0050	.20	.0140	.0000	0.9
7873	Sept. 1	Sept. 2	V. slight.	Slight.	0.75	4.30	1.50	.0006	.0248	.0236	.0012	.26	.0100	.0002	1.1
7989	Oct. 1	Oct. 2	V. slight.	Slight.	1.00	5.30	2.55	.0000	.0314	.0290	.0024	.33	.0100	.0001	1.3
8186	Nov. 2	Nov. 3	Slight.	Slight.	0.85	5.00	1.90	.0006	.0280	.0244	.0036	.40	.0070	.0001	1.3
8289	Dec. 2	Dec. 2	Distinct.	Slight.	1.30	6.10	2.25	.0016	.0406	.0352	.0054	.47	.0120	.0002	1.3
Av.	....	....	....	....	0.88	4.35	1.81	.0008	.0274	.0236	.0038	.26	.0112	.0001	1.1

Odor generally faintly vegetable, occasionally mouldy, sometimes none; frequently becomes somewhat stronger on heating. —— The samples were collected from the river near the old dam at the upper end of Reservoir No. 2, at a depth of one foot beneath the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	3	3	5	6	11	2	3	4	2	2	3	3
Number of sample, ...	6857	6955	7073	7164	7263	7369	7529	7742	7873	7989	8186	8289
PLANTS.												
Diatomaceæ, ...	**65**	**6**	**32**	**98**	**161**	**108**	**16**	**132**	**46**	**3**	**17**	**4**
Cyclotella, ...	0	0	0	0	0	0	0	39	40	0	0	0
Diatoma, ...	0	0	7	14	15	10	1	6	1	0	0	0
Fragilaria, ...	0	0	0	0	0	0	0	14	0	3	5	0
Melosira, ...	0	0	0	0	9	0	2	8	0	0	0	0
Meridion, ...	0	pr.	17	16	9	2	0	1	0	0	pr.	1
Navicula, ...	0	1	2	4	3	20	2	29	0	pr.	5	0
Nitzschia, ...	0	2	3	0	50	2	10	pr.	0	0	0	0
Stephanodiscus, ...	21	0	0	0	1	0	0	0	0	0	0	0
Synedra, ...	44	2	3	58	44	44	0	17	4	0	4	3
Tabellaria, ...	0	1	pr.	6	30	30	1	18	1	pr.	3	0

BOSTON.

Microscopical Examination — Concluded.

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ. Chroöcoccus, .	21	0	0	0	0	25	0	5	0	0	0	0
Algæ, ...	29	0	0	0	2	63	21	46	6	5	3	pr.
Chlorococcus, ...	1	0	0	0	pr.	50	17	27	3	0	2	pr.
Raphidium, ...	4	0	0	0	0	10	0	5	2	2	pr.	0
Scenedesmus, ...	pr.	0	0	0	pr.	0	pr.	2	1	0	1	0
Spirogyra, ...	0	0	0	0	2	0	0	12	0	0	0	0
Staurastrum, ...	1	0	0	0	pr.	3	pr.	pr.	0	0	pr.	0
Clothrix, ...	23	0	0	0	pr.	0	0	0	0	0	0	0
Zoöspores, ...	0	0	0	0	0	0	4	0	pr.	3	0	0
Fungi. Crenothrix, . . .	0	2	1	5	72	168	53	47	28	9	6	9
ANIMALS.												
Infusoria, ...	0	1	1	2	pr.	16	1	2	2	pr.	6	1
Dinobryon, ...	0	0	0	0	0	14	0	0	0	0	6	0
Monas, ...	0	0	0	2	0	2	1	2	1	pr.	pr.	1
Peridinium, ...	0	1	1	0	pr.	0	0	0	1	0	0	pr.
Miscellaneous. Zoöglœa, ...	48	13	200	204	230	272	7	122	118	75	30	116
TOTAL, ...	163	22	234	309	465	652	98	354	200	92	62	130

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 2, Framingham.*

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1891.														
6858	Jan. 1	Jan. 2	None.	V. slight.	1.10	4.65	1.80	.0006	.0192	.0174	.0018	.35	.0420	.0001	1.7
6956	Feb. 2	Feb. 3	V. slight.	V. slight.	0.75	3.50	1.15	.0012	.0158	.0140	.0018	.18	.0150	.0001	1.1
7074	Mar. 2	Mar. 3	V. slight.	V. slight.	0.55	4.55	1.95	.0000	.0160	.0132	.0028	.16	.0090	.0001	0.8
7165	Apr. 3	Apr. 4	V. slight.	Slight.	0.40	3.10	1.35	.0002	.0154	.0132	.0022	.19	.0050	.0002	0.8
7264	May 4	May 5	Slight.	Slight.	0.90	3.55	1.55	.0002	.0228	.0178	.0050	.22	.0090	.0000	1.1
7370	June 1	June 2	Distinct.	Cons.	0.70	3.90	1.90	.0002	.0258	.0216	.0042	.18	.0050	.0001	0.9
7530	July 2	July 3	V. slight.	Slight.	0.70	3.95	1.90	.0000	.0220	.0208	.0012	.20	.0050	.0001	0.8
7643	Aug. 3	Aug. 4	Distinct.	Slight.	0.65	3.45	1.25	.0004	.0242	.0206	.0036	.22	.0050	.0001	0.9
7774	Sept. 1	Sept. 2	Slight.	Cons	0.70	3.80	1.40	.0014	.0252	.0212	.0040	.22	.0070	.0002	0.8
7990	Oct. 1	Oct. 2	Distinct.	Decided.	0.75	4.00	2.55	.0002	.0290	.0228	.0062	.26	.0050	.0000	0.9
8137	Nov. 2	Nov. 3	Distinct.	Slight.	0.70	4.40	1.35	.0002	.0298	.0262	.0036	.34	.0070	.0001	0.9
8290	Dec. 2	Dec. 2	Distinct.	Slight.	0.80	5.35	2.00	.0008	.0306	.0238	.0068	.42	.0120	.0002	1.1
Av.	....	....	....	....	0.72	4.02	1.68	.0004	.0230	.0194	.0036	.24	.0105	.0001	1.0

Odor, generally very faint or none. No. 7990 was disagreeable, becoming much stronger on heating. — The samples were collected from the reservoir near the gate-house, at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

Microscopical Examination of Water from Reservoir No. 2, Framingham.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	3	5	6	11	2	3	4	2	2	3	3
Number of sample,	6858	6956	7074	7165	7264	7370	7530	7743	7874	7990	8187	8290
PLANTS.												
Diatomaceæ,	**18**	**3**	**37**	**37**	**196**	**269**	**130**	**649**	**225**	**223**	**376**	**280**
Cyclotella,	0	0	0	0	0	0	4	557	156	114	132	pr.
Diatoma,	2	0	1	15	7	11	4	0	4	60	1	pr.
Melosira,	0	0	0	5	4	0	3	20	10	3	0	0
Meridion,	0	1	28	4	2	1	0	0	0	2	0	0
Navicula,	0	0	1	1	0	pr.	pr.	1	3	3	pr.	0
Nitzschia,	10	1	3	0	0	2	0	0	0	0	0	0
Stephanodiscus,	0	0	0	0	0	60	90	1	0	0	0	0
Synedra,	2	1	pr.	12	172	194	29	68	52	40	242	280
Tabellaria,	4	0	4	0	11	1	0	2	pr.	1	1	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**5**	**4**	**12**	**6**	**0**	**0**	**0**
Chroöcoccus,	0	0	0	0	0	5	4	5	6	0	0	0
Spirulina,	0	0	0	0	0	0	0	7	0	0	0	0
Algæ,	**0**	**0**	**0**	**0**	**4**	**12**	**10**	**119**	**46**	**35**	**23**	**3**
Chlorococcus,	0	0	0	0	0	4	pr.	73	8	14	1	0
Closterium,	0	0	0	0	0	0	0	13	1	0	0	0
Conferva,	0	0	0	0	0	0	8	0	24	2	0	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	0	15	0
Raphidium,	0	0	0	0	3	5	0	20	10	14	4	2
Scenedesmus,	0	0	0	0	1	1	0	4	2	2	1	0
Staurastrum,	0	0	0	0	0	2	2	9	1	3	2	1
Fungi. Crenothrix,	**0**	**pr.**	**0**	**11**	**28**	**0**	**0**	**2**	**8**	**4**	**0**	**2**
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**
Infusoria,	**0**	**2**	**0**	**pr.**	**1**	**pr.**	**0**	**2**	**4**	**5**	**23**	**10**
Dinobryon,	0	0	0	0	0	0	0	0	pr.	0	6	3
Monas,	0	0	0	pr.	1	0	0	2	3	5	1	6
Peridinium,	0	2	0	0	pr.	0	0	0	0	0	0	pr.
Synura,	0	0	0	0	pr.	0	0	0	0	0	15	0
Trachelomonas,	0	0	0	0	0	pr.	0	0	1	pr.	1	1
Vermes. Conochilus,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**pr.**	**0**	**0**
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**pr.**	**0**	**0**
Miscellaneous, Zoöglœa,	**1**	**15**	**280**	**162**	**306**	**340**	**1**	**250**	**1,028**	**590**	**250**	**176**
TOTAL,	19	20	317	210	535	626	145	1,035	1,320	857	672	471

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Stony Brook, at Upper End of Reservoir No. 3, Southborough.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6860	Jan. 1	Jan. 2	V.slight.	V.slight.	1.00	6.15	2.10	.0076	.0206	.0186	.0020	.55	.0700	.0006	2.1
6957	Feb. 2	Feb. 3	Distinct.	Slight.	0.60	4.10	1.40	.0208	.0232	.0194	.0038	.20	.0310	.0004	1.6
7075	Mar. 2	Mar. 3	V.slight.	V.slight.	0.70	3.80	1.55	.0048	.0204	.0178	.0026	.32	.0250	.0004	1.4
7166	Apr. 3	Apr. 4	V.slight.	Cons.	0.60	4.05	1.50	.0006	.0178	.0144	.0034	.30	.0250	.0003	1.6
7265	May 4	May 5	Slight.	Slight.	1.10	5.40	2.20	.0040	.0280	.0252	.0028	.41	.0150	.0001	1.8
7371	June 1	June 2	Slight.	Slight.	0.90	5.95	2.65	.0036	.0368	.0302	.0066	.45	.0130	.0003	1.6
7531	July 2	July 3	V.slight.	Slight.	1.20	6.50	2.70	.0016	.0418	.0366	.0052	.34	.0090	.0002	1.8
7744	Aug. 3	Aug. 4	Slight.	Slight.	0.75	6.25	2.05	.0034	.0282	.0254	.0028	.73	.0100	.0001	2.3
7875	Sept. 1	Sept. 2	V.slight.	Slight.	0.70	7.40	3.55	.0004	.0308	.0282	.0026	1.19	.0020	.0002	2.5
7991	Oct. 1	Oct. 2	V.slight.	Slight.	0.75	7.90	2.55	.0014	.0322	.0298	.0024	.93	.0090	.0002	2.6
8188	Nov. 2	Nov. 3	V.slight.	V.slight.	0.75	8.10	1.85	.0032	.0298	.0248	.0050	.97	.0220	.0002	2.3
8291	Dec. 2	Dec. 2	Distinct.	Slight.	1.30	8.20	2.75	.0048	.0398	.0368	.0030	.71	.0400	.0007	2.3
Av.	....	....	....	....	0.86	6.15	2.24	.0047	.0291	.0256	.0035	.59	.0226	.0003	2.0

Odor, generally faintly vegetable, frequently mouldy or disagreeable. —— The samples were collected from Stony Brook, about fifty feet below the first road above Reservoir No. 3, at a depth of one foot beneath the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	3	5	6	11	2	3	4	2	2	3	3
Number of sample,	6860	6957	7075	7166	7265	7371	7531	7744	7875	7991	8188	8291
PLANTS.												
Diatomaceæ,	**6**	**1**	**45**	**257**	**115**	**10**	**36**	**168**	**263**	**16**	**8**	**21**
Cyclotella,	0	0	0	0	0	0	1	0	3	pr.	2	0
Diatoma,	2	0	1	1	8	pr.	0	0	0	0	0	0
Fragilaria,	0	1	0	0	4	5	0	0	0	2	0	10
Gomphonema,	0	pr.	0	64	1	4	0	0	0	0	0	0
Melosira,	0	0	0	2	15	0	22	150	258	8	6	0
Meridion,	2	0	1	82	5	0	pr.	0	0	0	0	0
Navicula,	1	pr.	0	2	3	1	pr.	pr.	0	3	0	0
Nitzschia,	1	0	43	60	5	0	6	0	0	0	0	0
Synedra,	pr.	pr.	pr.	46	74	0	7	18	2	3	pr.	11
Cyanophyceæ. Chroöcoccus,	**0**	**0**	**0**	**0**	**0**	**0**	**71**	**946**	**21**	**0**	**0**	**8**

BOSTON.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	0	0	0	1	0	0	47	88	26	1	4	0
Chlorococcus,	0	0	0	0	0	0	0	73	1	0	4	0
Closterium,	pr.	0	0	pr.	pr.	0	12	0	0	pr.	0	0
Eudorina,	0	0	0	0	0	0	0	1	5	0	0	0
Scenedesmus,	0	0	0	0	0	0	1	4	9	0	0	0
Staurastrum,	0	0	0	pr.	0	0	pr.	10	11	0	0	0
Zoöspores,	0	0	0	1	0	0	34	pr.	pr.	1	0	0
Fungi. Crenothrix,	0	1	3	38	38	1	15	55	1	448	19	2
ANIMALS.												
Infusoria,	0	0	0	pr.	pr.	21	61	5	4	1	23	7
Dinobryon,	0	0	0	0	0	21	35	2	0	0	23	4
Monas,	0	0	0	0	pr.	0	22	pr.	0	pr.	pr.	1
Peridinium,	0	0	0	0	0	0	2	1	1	0	0	0
Synura,	0	0	0	0	0	0	1	0	0	0	pr.	2
Trachelomonas,	0	0	0	pr.	pr.	pr.	1	2	3	1	0	0
Crustacea. Cyclops,	0	0	0	0	pr.	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	1	206	0	181	464	47	386	56	176	224	10	5
TOTAL,	7	208	48	477	617	79	616	1,318	491	690	64	43

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 3, Framingham.*

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid				Nitrates.	Nitrites.	
									Total.	Dissolved.	Sus-pended.				
	1891.														
6859	Jan. 1	Jan. 2	V. slight.	V. slight.	1.00	5.50	1.85	.0040	.0238	.0194	.0044	.44	.0520	.0004	2.1
6958	Feb. 2	Feb. 3	Slight.	Slight.	0.60	3.45	1.10	.0108	.0178	.0152	.0026	.22	.0250	.0003	1.3
7076	Mar. 2	Mar. 3	Distinct.	V. slight.	0.60	4.95	2.05	.0100	.0178	.0152	.0026	.23	.0210	.0004	1.7
7167	Apr. 3	Apr. 4	V. slight.	Slight.	0.40	3.85	1.30	.0032	.0126	.0106	.0020	.24	.0250	.0003	1.4
7266	May 4	May 5	Slight.	Slight.	0.60	3.85	1.40	.0002	.0238	.0196	.0042	.35	.0200	.0001	1.7
7372	June 1	June 2	Slight.	Slight.	0.70	4.65	1.00	.0012	.0262	.0204	.0058	.34	.0150	.0001	1.8
7532	July 2	July 3	Slight.	Cons.	0.60	4.55	1.80	.0014	.0298	.0212	.0086	.34	.0350	.0002	1.6
7745	Aug. 3	Aug. 4	Slight.	Slight.	0.45	5.00	2.00	.0012	.0252	.0220	.0032	.41	.0050	.0000	1.7
7876	Sept. 1	Sept. 2	Slight.	Slight.	0.55	4.90	1.50	.0050	.0248	.0236	.0012	.40	.0050	.0001	1.9
7992	Oct. 1	Oct. 2	Distinct.	Slight.	0.55	5.25	2.00	.0000	.0282	.0230	.0052	.45	.0070	.0000	1.7
8189	Nov. 2	Nov. 3	Distinct.	Cons.	0.50	5.00	2.20	.0002	.0284	.0214	.0070	.52	.0090	.0000	1.6
8292	Dec. 2	Dec. 2	Distinct.	Slight.	0.60	6.00	1.75	.0018	.0318	.0278	.0040	.68	.0090	.0001	1.8
Av.	....	....	....	....	0.60	4.75	1.66	.0032	.0242	.0200	.0042	.38	.0190	.0002	1.7

Odor, generally faintly vegetable or none, occasionally mouldy and unpleasant. —— The samples were collected from the reservoir near the gate-house, at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

Microscopical Examination of Water from Reservoir No. 3, Framingham.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
Day of examination,	3	3	5	6	11	2	3	4	2	2	3	3
Number of sample,	6859	6958	7076	7167	7266	7372	7532	7745	7876	7992	8189	8292
PLANTS.												
Diatomaceæ,	**51**	**1**	**5**	**77**	**819**	**15**	**238**	**1**	**22**	**5**	**330**	**197**
Asterionella,	49	0	0	6	5	4	0	0	0	5	305	64
Cyclotella,	0	0	0	0	0	0	88	1	20	0	4	0
Diatoma,	0	1	4	17	158	2	0	0	0	0	0	0
Meridion,	0	0	1	46	1	pr.	0	0	0	0	0	0
Navicula,	0	0	0	2	1	1	pr.	0	pr.	pr.	2	2
Nitzschia,	0	0	0	3	104	4	2	0	0	0	0	0
Synedra,	2	pr.	pr.	3	496	4	148	0	2	0	pr.	74
Tabellaria,	0	0	0	0	54	pr.	0	0	pr.	0	19	57
Cyanophyceæ,	**0**	**0**	**0**	**0**	**2**	**4**	**99**	**304**	**119**	**76**	**20**	**pr.**
Anabæna,	0	0	0	0	0	0	0	11	0	pr.	0	0
Chroöcoccus,	0	0	0	0	2	4	85	275	91	6	8	0
Clathrocystis,	0	0	0	0	0	pr.	1	5	3	0	2	pr.
Cœlosphærium,	0	0	0	0	0	0	8	3	15	34	3	0
Microcystis,	0	0	0	0	0	0	5	10	10	1	7	0
Nostoc,	0	0	0	0	0	0	0	0	0	35	0	0
Algæ,	**4**	**0**	**0**	**pr.**	**1**	**16**	**93**	**170**	**56**	**162**	**69**	**2**
Chlorococcus,	4	0	0	pr.	0	13	37	152	36	120	68	0
Cosmarium,	0	0	0	0	0	0	38	0	0	0	0	0
Pandorina,	0	0	0	0	0	0	pr.	12	2	2	0	0
Raphidium,	0	0	0	0	0	pr.	4	6	16	26	1	1
Scenedesmus,	0	0	0	0	1	1	3	0	0	0	0	1
Sorastrum,	0	0	0	0	pr.	2	11	0	pr.	0	0	pr.
Tetraspora,	0	0	0	0	0	0	0	0	2	14	0	0
Fungi.	**12**	**1**	**5**	**3**	**0**	**0**	**2**	**0**	**pr.**	**0**	**1**	**2**
Crenothrix,	pr.	1	5	3	0	0	2	0	pr.	0	0	2
Molds,	12	0	0	0	0	0	0	0	0	0	1	0
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**7**	**1**	**2**	**0**	**0**
Infusoria,	**0**	**0**	**0**	**7**	**3**	**1**	**2**	**2**	**31**	**39**	**2**	**39**
Dinobryon,	0	0	0	7	0	0	0	0	0	0	0	39
Monas,	0	0	0	pr.	3	0	1	pr.	12	pr.	0	pr.
Trachelomonas,	0	0	0	0	0	1	1	2	19	34	2	pr
Vorticella,	0	0	0	0	0	0	0	0	0	5	0	0
Crustacea,	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**pr.**	**pr.**	**pr.**	**pr.**	**0**
Bosmina,	0	0	0	0	0	0	0	0	0	pr.	0	0
Cyclops,	0	0	0	0	pr.	0	0	pr.	pr.	0	0	0
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	pr.	0
Miscellaneous, Zoöglœa,	**286**	**226**	**298**	**146**	**250**	**46**	**448**	**58**	**512**	**328**	**212**	**134**
TOTAL,	353	228	308	233	1,075	85	880	542	741	612	634	374

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Farm Pond, Framingham.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6862	Jan. 1	Jan. 2	Slight.	Slight.	0.90	5.70	1.50	.0072	.0278	.0232	.0046	.52	.0300	.0003	2.1
*6990	Feb. 6	Feb. 6	Slight.	V. slight.	0.10	2.35	0.45	.0046	.0134	.0114	.0020	.21	.0180	.0002	1.0
*7067	Mar. 2	Mar. 3	Slight.	V. slight.	0.10	2.60	0.95	.0000	.0158	.0096	.0062	.24	.0200	.0003	1.1
7158	Apr. 3	Apr. 4	Slight.	Cons., earthy.	0.10	4.75	1.30	.0024	.0164	.0144	.0020	.53	.0250	.0003	1.9
7268	May 4	May 5	V. slight.	Cons.	0.15	5.40	1.25	.0034	.0222	.0156	.0066	.58	.0150	.0002	2.2
7375	June 1	June 2	Slight.	V. slight.	0.10	4.65	1.15	.0016	.0180	–	–	.63	.0050	.0001	1.8
7510	July 1	July 2	Slight.	Slight.	0.05	4.95	0.95	.0020	.0164	.0138	.0026	.52	.0050	.0001	1.9
7746	Aug. 3	Aug. 4	Decided.	Slight.	0.10	4.80	1.85	.0000	.0238	.0170	.0068	.69	.0090	.0000	1.0
7878	Sept. 1	Sept. 2	Decided.	Slight.	0.10	5.55	2.20	.0000	.0238	.0156	.0082	.68	.0050	.0002	2.9
7997	Oct. 1	Oct. 3	Slight.	Cons.	0.10	5.50	2.00	.0040	.0214	.0180	.0034	.70	.0070	.0000	2.2
8191	Nov. 2	Nov. 3	V. slight.	V. slight.	0.00	5.35	1.20	.0028	.0198	.0172	.0026	.75	.0070	.0000	2.1
8294	Dec. 2	Dec. 3	V. slight.	Slight, earthy.	0.03	5.45	1.75	.0000	.0190	.0180	.0010	.81	.0100	.0000	2.2
Av.	....	....	....	....	0.16	5.21	1.51	.0023	.0212	.0170	.0042	.64	.0118	.0001	1.9

Odor, vegetable or none, sometimes mouldy. —— The samples were collected from the pond near the pumping station of the Framingham Water Company. For monthly record of height of water in this pond, see table at end of Boston analyses.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	12	5	6	12	2	2	4	2	3	3	3
Number of sample,	6862	6990	7067	7158	7268	7375	7510	7746	7878	7997	8191	8294
PLANTS.												
Diatomaceæ,	**7**	**0**	**0**	**340**	**4**	**1**	**2**	**6**	**20**	**10**	**44**	**14**
Asterionella,	5	0	0	222	0	0	0	0	0	9	4	8
Diatoma,	0	0	0	10	0	0	0	0	0	0	0	0
Fragilaria,	0	0	0	0	0	0	0	5	15	0	8	0
Melosira,	0	0	0	0	0	0	0	0	0	0	7	6
Navicula,	0	0	0	2	1	pr.	1	1	0	pr.	19	pr.
Synedra,	2	0	0	106	3	1	1	0	5	1	6	0

* These samples probably contained a large proportion of water from melting snow or ice, and are therefore omitted from the averages.

BOSTON.

Microscopical Examination — Concluded.

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	0	0	0	0	2	0	59	439	554	35	5	0
Anabæna,	0	0	0	0	0	0	0	111	2	0	0	0
Anabæna spores,	0	0	0	0	0	0	0	33	0	0	0	0
Chroöcoccus,	0	0	0	0	2	0	52	63	236	4	0	0
Clathrocystis,	0	0	0	0	0	0	7	221	288	5	0	0
Microcystis,	0	0	0	0	0	0	0	11	28	19	5	0
Nostoc,	0	0	0	0	0	0	0	0	0	7	0	0
Algæ,	350	0	16	14	0	4	0	27	0	118	4	0
Chlorococcus,	350	0	0	0	0	4	0	27	0	109	4	0
Closterium,	0	0	16	0	0	0	0	0	0	0	0	0
Eudorina,	0	0	0	0	0	0	0	0	0	9	0	0
Zoöspores,	0	0	0	14	0	0	0	0	0	0	0	0
Fungi. Crenothrix,	0	1	0	pr.	0	1	0	0	1	0	0	2
ANIMALS.												
Rhizopoda. Difflugia,	0	0	0	22	0	0	0	0	0	0	0	0
Infusoria,	5	3,165	1,038	681	1	0	0	1	1	pr.	4	0
Dinobryon,	3	3,164	140	98	0	0	0	0	0	0	pr.	0
Euglena,	0	0	0	0	0	0	0	0	0	0	4	0
Monas,	0	0	898	1	pr.	0	0	pr.	1	pr.	0	0
Peridinium,	0	1	0	0	1	0	0	0	0	0	0	0
Trachelomonas,	2	0	0	582	0	0	0	1	0	0	pr.	0
Vermes,	1	0	pr.	2	0	0	0	0	0	pr.	0	0
Anurea,	1	0	0	2	0	0	0	0	0	0	0	0
Rotatorian ova,	pr.	0	pr.	0	0	0	0	0	0	pr.	0	0
Crustacea,	0	0	0	pr.	pr.	0	0	pr.	0	pr.	0	0
Bosmina,	0	0	0	pr.	pr.	0	0	0	0	0	0	0
Cyclops,	0	0	0	pr.	0	0	0	pr.	0	pr.	0	0
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous. Zoögloea,	5	0	180	528	208	2	5	134	172	172	6	17
TOTAL,	368	3,166	1,234	1,587	215	8	66	607	748	335	63	33

BOSTON.

COCHITUATE SUPPLY. — *Chemical Examination of Water from Lake Cochituate in Wayland.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6861	Jan. 1	Jan. 2	Slight.	V. slight.	0.40	5.90	1.10	.0036	.0204	.0180	.0024	.50	.0300	.0002	2.2
6959	Feb. 2	Feb. 3	Slight.	Slight.	0.50	5.05	1.45	.0036	.0194	.0158	.0036	.41	.0380	.0003	1.9
7077	Mar. 2	Mar. 3	V. slight.	V. slight.	0.40	4.60	1.45	.0018	.0154	.0132	.0022	.40	.0250	.0002	1.8
7168	Apr. 3	Apr. 4	V. slight.	Slight.	0.40	5.45	1.80	.0006	.0182	.0140	.0042	.39	.0300	.0001	1.8
7267	May 4	May 5	Slight.	Cons.	0.30	4.15	1.20	.0008	.0200	.0144	.0056	.37	.0250	.0000	1.8
7373	June 1	June 2	Slight.	V. slight.	0.15	4.00	1.45	.0012	.0210	.0168	.0042	.39	.0220	.0002	1.7
7514	July 1	July 2	V. slight.	Slight.	0.15	4.50	1.80	.0000	.0172	.0124	.0048	.34	.0180	.0003	1.6
7748	Aug. 3	Aug. 4	Distinct.	Slight.	0.15	4.20	1.50	.0006	.0162	.0144	.0018	.46	.0180	.0001	1.8
7877	Sept. 1	Sept. 2	Distinct.	Slight.	0.00	4.40	1.70	.0008	.0182	.0144	.0038	.41	.0070	.0002	2.1
7993	Oct. 1	Oct. 2	Slight.	Slight.	0.01	4.40	1.20	.0000	.0168	.0142	.0026	.45	.0100	.0001	1.7
8190	Nov. 2	Nov. 3	Distinct.	Cons.	0.25	4.60	1.10	.0044	.0144	.0100	.0044	.46	.0200	.0001	1.9
8293	Dec. 2	Dec. 2	V. slight.	V. slight.	0.20	4.70	1.50	.0032	.0212	.0168	.0044	.47	.0120	.0003	1.8
Av.	....	....	....	....	0.24	4.66	1.44	.0017	.0182	.0145	.0037	.42	.0212	.0002	1.8

Odor, faintly vegetable or none, occasionally mouldy. —— The samples were collected in the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

Microscopical Examination.

[Number of organisms per cubic centimetor.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
Day of examination,	3	3	5	6	11	2	2	5	2	2	3	3
Number of sample,	6861	6959	7077	7168	7267	7373	7514	7748	7877	7993	8190	8293
PLANTS.												
Diatomaceæ,	**436**	**110**	**98**	**440**	**3,164**	**1,218**	**66**	**41**	**123**	**51**	**195**	**1,659**
Asterionella,	144	64	53	92	2,846	20	4	0	8	45	33	376
Cyclotella,	0	0	0	46	0	0	0	0	4	pr.	1	46
Fragilaria,	0	0	0	0	0	0	0	0	26	0	27	23
Melosira,	200	42	38	286	146	0	0	0	0	0	130	1,208
Nitzschia,	4	0	0	0	18	0	0	0	0	0	0	0
Stephanodiscus,	24	4	4	14	38	352	62	0	0	pr.	0	0
Synedra,	2	0	5	2	0	pr.	0	41	84	6	3	0
Tabellaria,	62	0	3	pr.	116	846	0	0	1	pr.	1	6
Cyanophyceæ,	**20**	**1**	**0**	**0**	**3**	**11**	**273**	**905**	**79**	**117**	**165**	**72**
Anabæna,	20	0	0	0	0	0	22	6	2	26	157	72
Chroöcoccus,	0	1	0	0	3	10	210	896	3	53	0	0
Clathrocystis,	0	pr.	0	0	0	1	0	1	1	3	5	pr.
Cœlosphærium,	0	0	0	0	pr.	pr.	6	0	1	1	0	0
Microcystis,	0	0	0	0	0	pr.	35	2	72	34	3	0

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov	Dec.
PLANTS — Con.												
Algæ,	5	0	12	23	0	67	36	132	203	46	14	16
Botryococcus,	0	0	0	0	0	0	31	0	1	0	0	0
Chlorococcus,	5	0	5	0	0	62	0	123	152	45	10	6
Closterium,	0	0	3	6	0	pr.	0	0	0	pr.	pr.	0
Pandorina,	0	0	0	0	0	2	1	4	0	0	0	0
Protococcus,	0	0	3	0	0	0	0	5	0	0	3	0
Raphidium,	0	0	pr.	0	0	3	0	0	50	1	1	0
Staurogenia,	0	0	0	0	0	0	4	pr.	0	0	pr.	0
Tetraspora,	0	0	0	0	0	0	0	0	0	0	0	10
Zoöspores,	0	0	1	17	0	0	0	0	0	0	0	0
Fungi. Crenothrix,	0	1	4	2	0	0	0	pr.	0	pr.	272	0
ANIMALS.												
Rhizopoda. Actinophrys,	pr.	0	pr.	2	0	2	0	0	0	0	3	4
Infusoria,	5	pr.	12	5	pr.	10	13	0	pr.	pr.	19	17
Dinobryon,	5	0	9	5	0	10	13	0	0	0	18	10
Monas,	0	0	1	pr.	0	0	0	0	0	0	0	4
Peridinium,	0	pr.	1	0	pr.	0	0	0	0	0	0	0
Trachelomonas,	0	0	1	pr.	pr.	pr.	0	0	pr.	pr.	1	3
Crustacea,	0	0	0	0	pr.	pr.	0	pr.	0	0	pr.	pr.
Bosmina,	0	0	0	0	pr.	pr.	0	0	0	0	0	0
Cyclops,	0	0	0	0	pr.	0	0	pr.	0	0	pr.	pr.
Miscellaneous, Zoöglœa,	24	214	126	124	78	0	1	3	0	1	31	82
TOTAL,	490	326	252	596	3,245	1,308	389	1,081	405	215	699	1,850

COCHITUATE WORKS. — *Chemical Examination of Water from a Faucet at the Massachusetts Institute of Technology.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6967	Jan. 2	Jan. 2	None.	V. slight.	0.50	5.15	2.00	.0022	.0170	.0154	.0016	.48	.0400	.0001	2.1
6968	Feb. 3	Feb. 3	V. slight.	V. slight.	0.50	4.65	1.45	.0016	.0156	.0140	.0016	.37	.0380	.0001	1.9
7081	Mar. 3	Mar. 3	V. slight.	V. slight.	0.45	4.20	1.80	.0004	.0126	.0120	.0006	.33	.0320	.0002	1.7
7169	Apr. 4	Apr. 4	V. slight.	Slight.	0.33	4.45	1.65	.0006	.0138	.0116	.0022	.34	.0300	.0001	1.6
7270	May 5	May 5	Slight.	V. slight.	0.30	4.15	1.90	.0000	.0158	.0130	.0028	.35	.0300	.0000	1.7
7378	June 2	June 2	V. slight.	Slight.	0.45	4.00	1.45	.0000	.0154	.0140	.0014	.33	.0220	.0001	1.6
7521	July 2	July 2	V. slight.	Slight.	0.35	4.05	1.40	.0000	.0148	.0130	.0018	.33	.0180	.0002	1.4
7751	Aug. 4	Aug. 4	V. slight.	Slight.	0.30	4.25	1.35	.0000	.0158	.0134	.0024	.31	.0190	.0000	1.4
7883	Sept. 2	Sept. 2	Slight.	Slight.	0.30	4.50	1.60	.0000	.0184	.0142	.0042	.36	.0090	.0002	1.7
7996	Oct. 2	Oct. 2	Slight.	Slight.	0.30	4.50	2.20	.0000	.0180	.0146	.0034	.37	.0120	.0000	1.7
8195	Nov. 3	Nov. 3	V. slight.	Slight.	0.30	4.20	1.60	.0006	.0166	.0116	.0050	.41	.0120	.0000	1.8
8284	Dec. 2	Dec. 2	V. slight.	Slight.	0.40	4.55	1.15	.0004	.0190	.0166	.0024	.47	.0100	.0001	1.7
Av.	....	....	....	....	0.37	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	1.7

Odor, none or very faintly vegetable.

BOSTON.

COCHITUATE WORKS. — *Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology.*

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	4	5	6	12	3	2	5	2	2	3	3
Number of sample,	6867	6968	7081	7169	7270	7378	7521	7751	7883	7996	8195	8284
PLANTS.												
Diatomaceæ,	241	84	128	249	1,245	198	98	126	60	37	155	466
Asterionella,	100	46	94	100	992	0	0	13	28	7	81	136
Cyclotella,	0	0	0	44	38	3	0	30	11	4	2	31
Diatoma,	0	0	1	0	6	3	0	0	0	0	0	0
Fragilaria,	0	0	0	0	0	0	0	5	0	14	62	23
Melosira,	124	33	28	86	86	4	5	2	0	8	0	124
Nitzschia,	0	pr.	pr.	0	4	0	0	0	0	0	0	0
Stephanodiscus,	8	5	3	7	22	100	92	3	0	0	1	0
Synedra,	0	pr.	pr.	8	80	0	1	73	4	4	8	120
Tabellaria,	9	0	2	4	17	88	0	0	17	0	1	32
Cyanophyceæ,	0	0	0	0	0	0	254	509	62	54	48	66
Anabæna,	0	0	0	0	0	0	2	3	1	8	20	60
Chroöcoccus,	0	0	0	0	0	0	240	474	41	7	0	4
Clathrocystis,	0	0	0	0	0	0	0	0	6	11	0	0
Cœlosphærium,	0	0	0	0	0	0	3	0	1	8	3	0
Microcystis,	0	0	0	0	0	0	9	7	13	20	5	2
Nostoc spores,	0	0	0	0	0	0	0	0	0	0	11	0
Oscillaria,	0	0	0	0	0	0	0	25	0	0	9	0
Algæ,	1	2	pr.	2	2	11	9	147	10	24	51	21
Chlorococcus,	0	2	pr.	0	2	4	4	146	0	22	25	18
Closterium,	0	pr.	0	2	0	4	1	pr.	0	0	1	2
Dictyosphærium,	0	0	0	0	0	0	0	0	0	0	24	0
Raphidium,	1	0	0	0	0	2	0	1	10	2	1	1
Scenedesmus,	0	0	0	0	0	1	4	pr.	pr.	pr.	0	0
Fungi. Crenothrix,	pr.	1	0	2	28	pr.	0	0	0	0	0	1
ANIMALS.												
Rhizopoda. Actinophrys,	pr.	pr.	0	0	0	pr.	0	0	0	0	pr.	1
Infusoria,	7	0	pr.	199	6	pr.	0	5	1	2	9	26
Dinobryon,	7	0	0	23	6	0	0	0	0	1	1	22
Dinobryon cases,	0	0	0	0	0	0	0	4	0	0	0	2
Peridinium,	0	0	pr.	2	0	0	0	0	0	0	0	2
Trachelomonas,	pr.	0	0	174	pr.	pr.	0	1	1	1	pr.	pr.
Synura,	0	0	0	0	0	0	0	0	0	0	3	0
Vorticella,	0	0	0	0	0	0	0	0	0	0	5	0
Crustacea. Cyclops,	pr.	0	0	0	0	0	0	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	44	24	42	16	172	33	96	30	66	92	3	38
TOTAL,	293	111	170	468	1,453	242	457	817	201	209	266	618

BOSTON

MYSTIC SUPPLY. — *Chemical Examination of Water from the Abbajona River at Winchester.*

[Parts per 100,000]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1890.	1890.													
6776	Dec. 2	Dec. 2	Slight, milky.	Slight.	0.15	14.05	2.15	.0800	.0532	.0454	.0078	2.22	.1600	.0030	5.3
	1891.	1891.													
6869	Jan. 5	Jan. 5	Slight.	Slight.	0.35	9.25	1.65	.0408	.0344	.0290	.0054	1.49	.1700	.0007	3.6
6971	Feb. 3	Feb. 4	Distinct, milky.	Slight.	0.40	6.95	2.20	.0296	.0230	.0194	.0036	0.87	.0900	.0007	3.0
7093	Mar. 5	Mar. 6	V. slight, milky.	Slight.	0.20	7.30	1.80	.0360	.0252	.0160	.0092	1.16	.0800	.0006	3.1
7171	Apr. 3	Apr. 7	Decided.	Heavy.	0.25	8.85	2.35	.0520	.0306	.0184	.0122	1.52	.1000	.0036	3.2
7279	May 5	May 6	Distinct.	Slight.	0.20	10.60	1.95	.0420	.0394	.0336	.0058	1.63	.0700	.0020	3.1
7382	June 2	June 4	Slight.	Cons., earthy.	0.10	12.85	2.45	.1192	.0414	.0272	.0142	1.35	.0700	.0030	4.3
7527	July 2	July 2	Distinct.	Cons., earthy.	0.25	11.85	2.55	.0274	.0726	.0544	.0182	1.90	.0580	.0020	4.2
7763	Aug. 10	Aug. 11	Decided.	Cons.	0.30	13.85	2.60	.0052	.0302	.0192	.0110	2.23	.0650	.0004	4.7
7886	Sept. 2	Sept. 3	Slight.	Cons.	0.10	16.10	4.10	.0156	.0250	.0204	.0046	2.40	.0900	.0010	5.3
8012	Oct. 5	Oct. 6	Slight.	Cons.	0.02	16.60	2.65	.0116	.0186	.0112	.0074	2.24	.0900	.0010	4.6
8199	Nov. 3	Nov. 4	Slight.	V slight.	0.05	18.15	2.10	.0606	.0386	.0320	.0066	3.19	.1250	.0070	6.0
8302	Dec. 3	Dec. 4	Distinct.	Slight.	0.10	14.85	2.00	.0160	.0214	.0184	.0030	2.62	.0900	.0022	5.1
Av.	....	....	....	....	0.19	12.40	2.35	.0412	.0349	.0265	.0084	1.91	.0968	.0021	4.3

Odor, generally vegetable and disagreeable. —— The samples were collected from the boat-house at Bacon Street, near where the river enters Mystic Lake.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1890.	1891.											
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	3	7	4	7	6	3	3	3	11	3	6	4	4
Number of sample, . .	6776	6869	6971	7093	7171	7279	7382	7527	7763	7886	8012	8199	8302
PLANTS.													
Diatomaceæ, ...	**149**	**94**	**3**	**251**	**16**	**399**	**119**	**807**	**705**	**57**	**117**	**20**	**38**
Asterionella, . . .	68	84	pr.	240	0	82	4	0	0	0	0	0	12
Cyclotella, . . .	0	0	0	0	0	0	0	0	1	2	5	0	0
Diatoma, ...	0	0	0	0	0	3	0	0	0	pr.	0	0	3
Fragilaria, . . .	0	0	0	0	0	0	0	0	492	17	0	0	0
Melosira, ...	4	7	1	0	0	0	0	0	5	0	0	3	7
Navicula, ...	pr.	1	1	0	5	pr.	0	2	9	26	36	7	1
Nitzschia, ...	1	2	0	0	10	148	5	796	0	0	0	0	0
Stephanodiscus, . .	0	0	0	11	0	0	0	2	0	0	0	0	0
Synedra, ...	74	pr.	1	0	0	166	110	0	194	12	76	3	15
Tabellaria, . . .	2	0	0	0	1	0	0	7	4	pr.	0	7	0
Cyanophyceæ, . .	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**27**	**27**	**pr.**	**0**	**0**	**0**
Chroöcoccus, . . .	0	0	0	0	0	0	0	27	0	0	0	0	0
Clathrocystis, . . .	0	0	0	0	0	0	0	0	27	pr.	0	0	0

BOSTON.

Microscopical Examination of Water from the Abbajona River at Winchester — Concluded.

[Number of organisms per cubic centimeter.]

	1890.	1891.											
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.													
Algæ,	**10**	**23**	**1**	**1,040**	**0**	**46**	**23**	**204**	**114**	**287**	**100**	**1**	**8**
Chlorococcus,	0	3	0	0	0	1	3	25	22	92	0	1	0
Cosmarium,	0	0	0	0	0	0	1	40	17	64	40	0	0
Pandorina,	0	0	0	0	0	0	pr.	2	3	0	1	0	0
Pleurococcus,	0	0	0	1,040	0	0	0	0	0	0	0	0	0
Polyedrium,	0	0	0	0	0	0	1	0	0	5	0	0	0
Protococcus,	0	15	1	0	0	0	0	58	0	0	0	0	0
Raphidium,	0	2	0	0	0	0	0	0	21	2	0	0	0
Scenedesmus,	10	3	0	0	0	44	18	23	21	124	52	0	8
Staurastrum,	0	0	0	0	0	1	0	56	30	pr.	7	0	0
Fungi,	**pr.**	**34**	**pr.**	**0**	**0**	**364**	**11**	**3**	**18**	**7**	**244**	**0**	**0**
Beggiatoa,	0	6	0	0	0	0	0	0	0	0	0	0	0
Crenothrix,	pr.	28	pr.	0	0	364	11	3	18	7	244	0	0
ANIMALS.													
Rhizopoda. Difflugia,	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**0**	**0**	**pr.**	**17**	**0**	**pr.**	**1**	**12**	**95**	**72**	**58**	**0**	**pr.**
Dinobryon,	0	0	0	8	0	0	0	0	pr.	0	0	0	0
Glenodinium,	0	0	0	4	0	0	0	0	pr.	0	0	0	0
Monas,	0	0	0	0	0	pr.	pr.	5	2	6	2	0	pr.
Peridinium,	0	0	pr.	0	0	0	0	1	44	58	0	0	0
Peridinium cases,	0	0	0	0	0	0	0	0	48	0	56	0	0
Trachelomonas,	0	0	0	5	0	pr.	1	6	1	8	0	0	pr.
Crustacea. Cyclops,	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous, Zoöglœa,	**356**	**672**	**264**	**38**	**1,146**	**328**	**384**	**680**	**278**	**730**	**236**	**23**	**132**
TOTAL,	515	823	268	1,349	1,164	1,137	518	1,733	1,237	1,153	755	44	178

MYSTIC SUPPLY. — *Chemical Examination of Water from Mystic Lake.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6871	Jan. 5	Jan. 6	V. slight.	Slight.	0.15	9.65	2.55	.0280	.0178	.0150	.0028	1.30	.2500	.0011	3.4
6973	Feb. 3	Feb. 4	Distinct, milky.	Slight	0.30	6.90	1.80	.0440	.0284	.0232	.0052	1.10	.0900	.0008	2.9
7085	Mar. 3	Mar. 4	Distinct.	V. slight.	0.20	6.95	1.55	.0344	.0314	.0262	.0052	1.08	.0800	.0008	3.2
7172	Apr. 3	Apr. 7	Distinct.	Cons.	0.13	8.05	1.60	.0416	.0202	.0140	.0062	1.33	.1100	.0020	3.1
7278	May 5	May 6	Distinct.	Slight.	0.20	8.70	1.75	.0162	.0236	.0186	.0050	1.35	.0600	.0018	3.2
7383	June 2	June 4	Slight.	V. slight.	0.08	9.60	1.30	.0028	.0260	.0188	.0072	1.57	.0700	.0007	3.5
7526	July 2	July 2	Slight.	V. slight.	0.10	9.70	1.25	.0030	.0254	.0234	.0020	1.70	.0500	.0025	3.8
7762	Aug. 10	Aug. 11	Distinct.	Slight	0.15	10.75	4.00	.0012	.0310	.0188	.0122	2.18	.0250	.0004	3.6
7885	Sept. 2	Sept. 3	Slight.	Slight.	0.08	10.40	1.55	.0010	.0250	.0202	.0048	1.60	.0150	.0010	3.6
8011	Oct. 5	Oct. 6	Distinct.	Slight.	0.02	11.30	1.50	.0030	.0262	.0184	.0078	1.75	.0070	.0005	3.8
8200	Nov. 3	Nov. 4	Slight.	Slight.	0.05	10.90	1.20	.0166	.0220	.0178	.0042	1.82	.0500	.0010	3.5
8301	Dec. 3	Dec. 4	Slight.	Slight.	0.05	11.15	1.70	.0320	.0130	.0104	.0026	2.19	.0700	.0020	3.8
Av.	....	....	....	....	0.13	9.50	1.81	.0186	.0242	.0187	.0055	1.58	.0731	.0012	3.5

Odor, generally mouldy or vegetable, frequently disagreeable, occasionally none. — The samples were collected from the lake near the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

Microscopical Examination of Water from Mystic Lake.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	4	6	7	12	3	3	11	3	6	3	4
Number of sample,	6871	6973	7085	7172	7278	7383	7526	7762	7885	8011	8200	8301
PLANTS.												
Diatomaceæ,	132	5	2	44	8,536	1,471	125	61	129	38	48	108
Asterionella,	98	2	2	10	1,728	2	1	0	1	0	2	0
Diatoma,	4	0	0	3	0	6	0	0	0	0	0	54
Fragilaria,	0	0	0	0	0	0	0	34	10	8	0	5
Melosira,	1	1	0	2	0	1	0	0	0	0	9	5
Navicula,	0	0	pr.	1	0	pr.	1	2	pr.	3	pr.	0
Nitzschia,	3	0	0	0	1,176	6	36	0	0	0	0	0
Striatella,	0	0	0	0	0	0	0	0	0	7	0	0
Synedra,	26	2	pr.	28	5,632	1,456	87	25	118	20	37	44
Cyanophyceæ. Clathrocystis,	0	0	0	0	0	0	0	14	3	0	0	0
Algæ,	1	1	0	6	112	125	137	110	162	315	56	41
Chlorococcus,	0	0	0	0	0	102	5	46	5	0	18	0
Cosmarium,	0	0	0	0	2	2	11	20	82	104	8	16
Pandorina,	0	0	0	0	0	0	0	3	4	1	0	0
Pediastrum,	0	0	0	0	0	0	1	1	2	2	0	0
Polyedrium,	0	0	0	0	0	0	0	0	8	0	0	0
Raphidium,	0	0	0	0	4	0	0	1	5	0	0	2
Scenedesmus,	1	0	0	0	104	1	2	24	28	76	15	20
Sorastrum,	0	0	0	0	0	pr.	0	0	6	0	0	pr.
Staurastrum,	0	0	0	0	0	1	118	15	22	132	15	3
Tetraspora,	0	0	0	0	0	19	0	0	0	0	0	0
Zoöspores,	0	1	0	6	2	0	0	0	0	0	0	0
Fungi,	578	pr.	50	48	14	0	0	0	0	0	25	4
Crenothrix,	578	pr	0	48	14	0	0	0	0	0	25	4
Molds,	0	0	50	0	0	0	0	0	0	0	0	0
ANIMALS.												
Infusoria,	0	0	pr.	1	0	1	9	1,550	624	560	1	1
Monas,	0	0	0	0	0	0	0	0	2	0	1	1
Peridinium,	0	0	pr.	0	0	0	9	734	340	312	0	0
Peridinium cases,	0	0	0	0	0	0	0	816	282	248	0	0
Trachelomonas,	0	0	0	1	0	1	0	pr.	0	0	0	0
Miscellaneous, Zoöglœa,	160	612	918	556	184	4	26	6	110	248	9	78
TOTAL,	871	618	970	655	8,846	1,601	297	1,741	1,028	1,161	139	232

BOSTON.

JAMAICA POND SUPPLY. — *Chemical Examination of Water from Jamaica Pond, collected at the surface.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6940	Jan. 24	Jan. 26	V. slight.	V. slight.	0.0	-	-	.0600	.0240	.0192	.0048	-	.0300	.0007	-
6998	Feb. 11	Feb. 12	Slight.	Slight.	0.0	-	-	.0480	.0266	.0202	.0064	-	.0400	.0005	-
7043	Feb. 24	Feb. 24	Slight.	Slight.	0.0	-	-	.0360	.0282	.0190	.0092	.79	.0380	.0005	-
7177	Apr. 7	Apr. 7	Distinct.	Slight.	0.0	-	-	.0152	.0252	.0178	.0074	-	.0600	.0005	-
7254	Apr. 29	Apr. 29	Distinct.	Slight, green.	0.0	-	-	.0000	.0330	.0240	.0090	-	.0700	.0005	-
7308	May 13	May 13	Distinct.	Cons., green.	0.0	-	-	.0040	.0312	.0228	.0084	-	.0400	.0003	-
7358	May 27	May 27	Slight.	Cons.	0.0	-	-	.0054	.0268	.0238	.0030	.76	.0500	.0010	-
7427	June 10	June 10	V. slight.	V. slight.	0.0	7.65	1.40	.0018	.0206	.0188	.0018	.78	.0500	.0008	-
7499	June 29	June 30	Distinct.	Slight, white.	0.0	-	-	.0000	.0304	.0230	.0074	-	.0300	.0007	-
7558	July 14	July 14	Slight.	Slight, white.	0.0	-	-	.0004	.0312	.0246	.0066	-	.0030	.0010	-
7755	Aug. 6	Aug. 7	Distinct.	Slight.	0.0	6.75	1.95	.0000	.0234	.0188	.0046	-	.0020	.0000	-
Av.	....	....	....	....	0.0	7.20	1.67	.0155	.0273	.0211	.0062	.78	.0375	.0006	-

Odor, generally none, sometimes vegetable, rarely disagreeable; on heating it is generally unpleasant and frequently disagreeable. —— The samples were collected from the pond, near the northerly shore.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Feb.	Apr.	Apr.	May.	May.	June.	June.	July.	Aug.
Day of examination,	27	14	26	8	30	14	28	11	30	15	7
Number of sample,	6940	6998	7043	7177	7254	7308	7358	7427	7499	7558	7755
PLANTS.											
Diatomaceæ,	**1,169**	**2,921**	**4,152**	**684**	**2,736**	**510**	**5**	**5**	**19**	**13**	**0**
Asterionella,	34	2	0	54	0	6	0	4	2	0	0
Cyclotella,	0	0	0	0	4	0	0	pr.	2	pr.	0
Melosira,	13	7	8	6	2	0	0	0	0	0	0
Nitzschia,	0	0	0	0	26	12	0	0	0	0	0
Stephanodiscus,	0	0	0	0	0	0	0	1	8	0	0
Synedra,	1,122	2,912	4,144	624	2,704	492	1	pr.	4	13	0
Tabellaria,	0	0	0	0	0	0	4	pr.	3	0	0
Cyanophyceæ,	**0**	**0**	**16**	**0**	**22**	**0**	**53**	**0**	**262**	**106**	**1,047**
Anabæna,	0	0	16	0	1	0	0	0	0	0	8
Chroöcoccus,	0	0	0	0	21	0	53	0	208	105	1,030
Clathrocystis,	0	0	0	0	0	0	0	0	0	1	9
Microcystis,	0	0	0	0	0	0	0	0	54	pr.	pr.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.										
	Jan.	Feb.	Feb.	Apr.	Apr.	May.	May.	June	June.	July.	Aug.
PLANTS — Con.											
Algæ,	**178**	**262**	**340**	**28**	**709**	**335**	**775**	**224**	**328**	**108**	**40**
Chlorococcus,	4	112	50	6	61	16	636	183	22	0	4
Closterium,	2	3	6	0	12	31	21	32	302	107	1
Cosmarium,	146	132	152	19	352	196	28	1	3	pr.	8
Pandorina,	0	0	0	0	6	0	36	5	0	pr.	0
Pediastrum,	0	2	0	0	2	4	0	pr.	0	0	0
Protococcus,	3	0	128	0	1	0	0	0	0	0	0
Raphidium,	3	6	0	0	0	4	40	0	0	0	0
Scenedesmus,	20	7	4	3	268	64	8	pr.	0	1	0
Sorastrum,	0	0	0	0	2	7	0	1	0	0	0
Staurastrum,	0	0	0	0	5	13	11	2	1	pr.	27
Fungi. Crenothrix,	**9**	**2**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.											
Rhizopoda,	pr.	pr.	pr.	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**2**
Actinophrys,	0	0	0	0	0	0	0	0	0	0	2
Difflugia,	pr.	pr.	0	0	3	0	0	0	0	0	0
Infusoria,	**1**	**2**	**22**	**2**	**24**	**1**	**0**	**0**	**7**	**39**	**30**
Ceratium,	0	0	0	0	0	0	0	0	7	36	22
Glenodinium,	0	0	0	0	3	0	0	0	0	0	3
Peridinium,	1	2	22	2	21	1	0	0	0	3	5
Vermes,	**0**	**0**	**0**	**0**	**3**	**0**	**0**	pr.	**2**	**2**	pr.
Anurea,	0	0	0	0	1	0	0	pr.	2	0	pr.
Rotatorian ova,	0	0	0	0	2	0	0	0	0	2	pr.
Crustacea,	**0**	pr.	pr.	pr.	pr.	pr.	**0**	**0**	**0**	pr.	**0**
Bosmina,	0	0	0	0	0	pr.	0	0	0	0	0
Cyclops,	0	pr.	pr.	pr.	pr.	pr.	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	**426**	**0**	**176**	**256**	**448**	**140**	**370**	**36**	**48**	**23**	**0**
TOTAL,	1,783	3,187	4,710	950	3,945	986	1,203	265	666	291	1,119

Chemical Examination of Water from Jamaica Pond, collected ten feet beneath the surface.

[Parts per 100,000.]

Number.	Date of: Collection.	Date of: Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as: Nitrates.	Nitrogen as: Nitrites.	Hardness.
	1891.														
6941	Jan. 24	Jan. 26	V. slight.	V. slight.	0.0	-	-	.0606	.0248	.0180	.0068	-	.0320	.0007	-
6999	Feb. 11	Feb. 12	Slight.	Slight.	0.0	-	-	.0496	.0302	.0196	.0106	-	.0400	.0005	-
7044	Feb. 24	Feb. 2[illegible]	Slight.	Slight, fibrous.	0.0	-	-	.0360	.0274	.0174	.0100	.79	.0400	.0005	-
7178	Apr. 7	Apr. 7	Distinct.	Slight.	0.0	-	-	.0144	.0262	.0174	.0088	-	.0600	.0005	-
7255	Apr. 29	Apr. 29	Distinct.	Slight, green.	0.0	-	-	.0000	.0342	.0224	.0118	-	.0650	.0007	-
7309	May 13	May 13	Distinct.	Slight, green.	0.0	-	-	.0042	.0320	.0204	.0116	-	.0400	.0005	-
7359	May 27	May 27	Slight.	Cons., White.	0.0	-	-	.0050	.0294	.0204	.0090	-	.0500	.0010	-

Odor, faintly vegetable or none; on heating it was decidedly vegetable and fishy in February and disagreeable on May 13. —— The samples were collected from the north-easterly portion of the pond where the water is deepest.

BOSTON.

Microscopical Examination of Water from Jamaica Pond, collected ten feet beneath the surface.

[Number of organisms per cubic centimeter.]

	1891.						
	Jan.	Feb.	Feb.	Apr.	Apr.	May.	May.
Day of examination,	27	14	26	8	30	14	28
Number of sample,	6941	6999	7044	7178	7255	7359	7359
PLANTS.							
Diatomaceæ,	**2,050**	**2,996**	**3,890**	**1,537**	**2,761**	**503**	**3**
Asterionella,	5	0	0	98	0	5	2
Melosira,	1	13	82	11	2	2	0
Nitzschia.	0	3	0	0	23	0	0
Synedra,	2,044	2,980	3,808	1,428	2,736	496	1
Cyanophyceæ,	**0**	**0**	**20**	**5**	**14**	**0**	**332**
Anabæna,	0	0	12	0	0	0	0
Chroöcoccus,	0	0	8	5	14	0	332
Algæ,	**217**	**211**	**110**	**214**	**833**	**321**	**960**
Chlorococcus,	15	96	0	0	46	48	718
Closterium,	4	2	0	5	17	15	24
Cosmarium,	110	98	58	58	440	176	24
Palmella,	0	0	0	150	0	0	0
Pandorina,	0	0	0	0	1	0	20
Pediastrum,	3	1	0	0	10	3	1
Protococcus,	35	0	40	0	20	0	0
Raphidium,	4	0	0	0	0	2	116
Scenedesmus,	46	14	12	1	292	72	1
Staurastrum,	0	0	0.	pr.	7	5	26
Fungi. Crenothrix,	10	1	4	0	0	0	0
ANIMALS.							
Rhizopoda. Difflugia,	1	0	2	3	1	0	0
Infusoria,	1	pr.	6	1	17	9	0
Dinobryon,	0	0	0	0	0	8	0
Peridinium,	1	pr.	6	1	17	1	0
Vermes. Rotatorian ova,	0	0	6	0	0	0	0
Crustacea,	pr.	pr.	pr.	pr.	pr.	1	0
Bosmina,	0	0	0	0	0	pr.	0
Cyclops,	pr.	pr.	pr.	pr.	pr.	pr.	0
Daphnia,	0	0	0	0	0	pr.	0
Entomostracan ova,	0	0	0	0	0	1	0
Miscellaneous. Zoöglœa,	294	0	120	68	460	320	644
TOTAL,	2,573	3,208	4,158	1,828	4,086	1,155	1,939

BOSTON.

Chemical Examination of Water from Jamaica Pond, collected twenty feet beneath the surface.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6942	Jan. 24	Jan. 26	V. slight.	V. slight.	0.0	-	-	.0560	.0226	.0172	.0054	-	.0300	.0007	-
7000	Feb. 11	Feb. 12	Slight.	Slight, green.	0.0	-	-	.0504	.0308	.0198	.0110	-	.0400	.0007	-
7045	Feb. 24	Feb. 24	Slight.	Slight, fibr'us.	0.0	-	-	.0400	.0262	.0174	.0088	.78	.0400	.0005	-
7179	Apr. 7	Apr. 7	Distinct.	Slight.	0.0	-	-	.0136	.0292	.0196	.0096	-	.0600	.0003	-
7256	Apr. 29	Apr. 29	Slight.	Slight, green.	0.0	-	-	.0120	.0344	.0220	.0124	-	.0680	.0005	-
7310	May 13	May 13	Distinct.	Cons., green.	0.0	-	-	.0130	.0318	.0200	.0118	-	.0400	.0005	-
7360	May 27	May 27	Slight.	Cons., fibr'us.	0.0	-	-	.0188	.0250	.0210	.0040	.75	.0600	.0010	-

Odor, generally very faintly vegetable or none, somewhat disagreeable May 13. The February samples were vegetable and fishy on heating and the sample for May 13 disagreeable.—— The samples were collected from the north-easterly portion of the pond where the water is deepest.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Feb.	Apr.	Apr.	May.	May.
Day of examination,	27	14	26	8	30	14	28
Number of sample,	6942	7000	7045	7179	7256	7310	7360
PLANTS.							
Diatomaceæ,	**1,948**	**2,737**	**2,728**	**1,129**	**2,553**	**1,074**	**0**
Asterionella,	0	9	0	56	3	2	0
Melosira,	4	0	0	25	2	0	0
Nitzschia,	0	0	0	0	4	4	0
Synedra,	1,944	2,728	2,728	1,048	2,544	1,068	0
Cyanophyceæ,	**0**	**0**	**22**	**0**	**29**	**0**	**140**
Anabæna,	0	0	10	0	8	0	0
Chroöcoccus,	0	0	12	0	21	0	140
Algæ,	**207**	**174**	**126**	**78**	**541**	**508**	**265**
Chlorococcus,	19	70	0	0	23	35	107
Closterium,	0	10	8	13	104	96	72
Cosmarium,	132	76	72	56	180	176	0
Pediastrum,	1	1	0	0	1	4	1
Protococcus,	5	0	42	9	14	0	0
Raphidium,	16	0	0	0	0	6	48
Scenedesmus,	34	16	4	pr.	216	180	14
Sorastrum,	0	1	0	0	2	1	2
Staurastrum,	0	0	0	pr.	1	8	21
Fungi. Crenothrix,	**20**	**1**	**10**	**pr.**	**0**	**0**	**2**

BOSTON.

Microscopical Examination of Water from Jamaica Pond, collected twenty feet beneath the surface — Concluded.

[Number of organisms per cubic centimeter.]

	1891.						
	Jan.	Feb.	Feb.	April.	April.	May.	May.
ANIMALS.							
Rhizopoda. Difflugia,	1	0	0	8	27	1	0
Infusoria,	2	0	4	12	6	0	2
Peridinium,	pr.	0	2	11	5	0	2
Trachelomonas,	2	0	2	0	0	0	0
Glenodinium,	0	0	0	1	1	0	0
Crustacea,	pr.	pr.	pr.	pr.	pr.	3	0
Bosmina,	0	0	pr.	0	pr.	0	0
Cyclops,	pr.	pr.	pr.	pr.	pr.	pr.	0
Diaptomus,	0	0	0	0	pr.	0	0
Entomostracan ova,	0	0	0	0	0	3	0
Miscellaneous. Zoöglœa,	264	0	96	66	300	236	320
TOTAL,	2,442	2,912	2,986	1,293	3,456	1,820	729

Chemical Examination of Water from Jamaica Pond, collected thirty feet beneath the surface.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1891.														
6943	Jan. 24	Jan. 26	V. slight.	Slight, green.	0.0	–	–	.0592	.0232	.0188	.0044	–	.0350	.0007	–
7001	Feb. 11	Feb. 12	Slight.	Slight, green.	0.0	–	–	.0496	.0306	.0222	.0084	–	.0400	.0005	–
7046	Feb. 24	Feb. 24	Slight.	Slight, fibr'us.	0.0	–	–	.0400	.0258	.0194	.0064	.80	.0400	.0005	–
7180	Apr. 7	Apr. 7	Slight.	Cons., fibr'us.	0.0	–	–	.0168	.0282	.0172	.0110	–	.0600	.0003	–
7257	Apr. 29	Apr. 29	Slight.	Slight, green.	0.0	–	–	.0224	.0240	.0178	.0062	–	.0680	.0005	–
7311	May 13	May 13	Slight.	Cons., green.	0.0	–	–	.0256	.0240	.0158	.0082	–	.0400	.0005	–
7361	May 27	May 27	Slight.	Slight, green.	0.0	–	–	.0288	.0244	.0182	.0062	–	.0600	.0008	–
7428	June 10	June 10	Distinct.	Slight.	0.0	–	–	.0264	.0184	.0164	.0020	.79	.0530	.0008	–
7500	June 29	June 30	Slight.	Slight.	0.1*	–	–	.0294	.0200	.0156	.0044	–	.0550	.0010	–
7559	July 14	July 14	Slight.	Slight.	0.0	–	–	.0344	.0222	.0142	.0080	–	.0500	.0002	–
7756	Aug. 6	Aug. 7	Distinct.	Slight, green.	0.0	6.70	1.90	.0130	.0194	.0160	.0034	–	.0350	.0005	–

Odor, generally faintly vegetable or none, very disagreeable in July. On heating it was vegetable and fishy in February and disagreeable in August. — The samples were collected from the north-easterly portion of the pond where the water is deepest.

* After standing three days.

BOSTON

Microscopical Examination of Water from Jamaica Pond, collected thirty feet beneath the surface.

[Number of organisms per cubic centimeter.]

	1891.										
	Jan.	Feb.	Feb.	April.	April.	May.	May.	June.	June.	July.	Aug.
Day of examination,	27	14	26	8	30	14	28	11	30	15	7
Number of sample,	6943	7001	7046	7180	7257	7311	7361	7428	7500	7559	7756
PLANTS.											
Diatomaceæ,	**1,476**	**1,453**	**2,796**	**1,225**	**2,197**	**2,034**	**816**	**48**	**14**	**17**	**6**
Asterionella,	6	0	8	50	8	2	0	7	12	4	0
Cyclotella,	0	0	0	0	0	0	0	0	0	4	6
Melosira,	2	1	28	41	5	0	0	0	0	1	0
Nitzschia,	0	0	0	0	8	0	0	0	0	0	0
Synedra,	1,468	1,452	2,760	1,134	2,176	2,032	816	41	2	8	0
Cyanophyceæ,	**0**	**0**	**10**	**0**	**4**	**0**	**33**	**0**	**191**	**129**	**574**
Anabæna,	0	0	10	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	4	0	33	0	112	47	516
Microcystis,	0	0	0	0	0	0	0	0	79	82	58
Algæ,	**169**	**159**	**146**	**85**	**226**	**204**	**640**	**62**	**343**	**100**	**213**
Botryococcus,	0	0	0	0	0	0	0	0	11	0	0
Chlorococcus,	21	76	12	2	0	4	105	26	78	0	46
Closterium,	1	3	2	15	23	48	96	8	182	87	140
Cosmarium,	100	68	38	48	120	84	192	1	41	10	7
Palmella,	0	0	0	0	0	0	16	0	0	0	0
Pediastrum,	pr.	2	0	pr.	4	0	0	0	1	1	0
Protococcus,	7	0	88	10	15	0	0	0	0	0	0
Raphidium,	6	6	0	0	0	0	22	0	0	0	0
Scenedesmus,	34	4	6	2	60	68	200	24	21	0	1
Staurastrum,	0	pr.	0	pr.	4	0	9	3	9	2	19
Tetraspora,	0	0	0	8	0	0	0	0	0	0	0
Fungi. Crenothrix,	**24**	**3**	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
ANIMALS.											
Rhizopoda. Difflugia,	**0**	**pr.**	**0**	**8**	**15**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**0**	**pr.**	**0**	**7**	**5**	**4**	**0**	**5**	**4**	**18**	**50**
Ceratium,	0	0	0	0	0	0	0	5	4	18	31
Ceratium cases,	0	0	0	0	0	0	0	0	0	0	19
Peridinium,	0	0	0	5	0	2	0	0	0	pr.	0
Trachelomonas,	0	pr.	0	2	5	2	0	0	0	pr.	0
Vermes. Anuræa,	**0**	**0**	**0**	**0**	**1**	**3**	**0**	**0**	**pr.**	**0**	**1**
Crustacea,	**pr.**	**pr.**	**pr.**	**pr.**	**1**	**pr.**	**0**	**pr.**	**0**	**pr.**	**pr.**
Bosmina,	0	0	pr.	0	0	0	0	0	0	0	0
Cyclops,	pr.	pr.	pr.	pr.	pr.	pr.	0	0	0	pr.	pr.
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	0
Entomostracan ova,	0	0	0	0	1	0	0	0	0	0	0
Entomostracan remains,	0	0	0	0	0	0	0	pr.	0	0	0
Miscellaneous. Zoöglœa,	**268**	**9**	**96**	**118**	**248**	**192**	**448**	**23**	**24**	**36**	**72**
TOTAL,	1,957	1,624	3,060	1,443	2,697	2,437	1,937	138	576	304	916

BOSTON.

Chemical Examination of Water from Jamaica Pond, collected forty feet beneath the surface.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6944	Jan. 24	Jan. 26	V. slight.	Slight, green.	0.0	-	-	.0600	.0230	.0176	.0054	-	.0320	.0007	-
7002	Feb. 11	Feb. 12	Slight.	Slight.	0.0	-	-	.0560	.0230	.0198	.0032	-	.0400	.0006	-
7047	Feb. 24	Feb. 24	Slight.	Cons., fibrous.	0.0	-	-	.0376	.0290	.0182	.0108	.80	.0400	.0005	-
7181	Apr. 7	Apr. 7	Slight.	Slight, earthy.	0.0	-	-	.0136	.0300	.0182	.0118	-	.0620	.0004	-
7258	Apr. 29	Apr. 29	Slight.	Slight.	0.0	-	-	.0216	.0206	.0176	.0030	-	.0680	.0005	-
7313	May 13	May 13	Slight.	Slight.	0.0	-	-	.0360	.0270	.0200	.0070	-	.0500	.0003	-
7362	May 27	May 27	Slight.	Slight, green.	0.0	-	-	.0400	.0266	.0190	.0076	.78	.0500	.0008	-

Odor, none or faintly vegetable; on heating it became vegetable and fishy in February. —— The samples were collected from the north-easterly portion of the pond where the water is deepest.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Feb.	April.	April.	May.	May.
Day of examination,	27	14	26	8	30	14	28
Number of sample,	6944	7002	7047	7181	7258	7313	7362
PLANTS.							
Diatomaceæ,	**1,185**	**1,931**	**3,030**	**1,868**	**1,768**	**1,012**	**842**
Asterionella,	70	0	0	96	15	4	6
Melosira,	5	11	6	44	5	0	0
Nitzschia,	0	0	0	0	4	0	0
Synedra,	1,110	1,920	3,024	1,728	1,744	1,008	836
Cyanophyceæ,	**0**	**0**	**16**	**0**	**0**	**0**	**21**
Anabæna,	0	0	16	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	21
Algæ,	**138**	**62**	**82**	**76**	**99**	**79**	**415**
Chlorococcus,	0	8	0	0	4	3	120
Closterium,	10	3	0	24	14	9	22
Cosmarium,	88	48	32	25	45	31	168
Pediastrum,	1	0	0	0	2	0	1
Protococcus,	5	0	40	18	0	0	0
Raphidium,	6	0	0	0	0	0	0
Scenedesmus,	28	3	10	1	23	36	104
Tetraspora,	0	0	0	8	0	0	0
Zoöspores,	0	0	0	0	11	0	0
Fungi. Crenothrix,	**42**	**26**	**16**	**0**	**6**	**1**	**14**

BOSTON.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.						
	Jan.	Feb.	Feb.	April.	April.	May.	May.
ANIMALS.							
Rhizopoda. Difflugia,	0	1	2	8	13	0	0
Infusoria,	1	1	6	9	7	0	1
Monas,	0	0	0	0	0	0	0
Peridinium,	1	pr.	6	6	6	0	0
Trachelomonas,	0	1	0	3	1	0	1
Crustacea,	pr.	pr.	pr.	pr.	pr.	0	0
Bosmina,	0	pr.	0	0	0	0	0
Cyclops,	pr.	pr.	pr.	pr.	pr.	0	0
Miscellaneous. Zoöglœa,	174	48	152	76	284	152	432
TOTAL,	1,540	2,069	3,304	2,037	2,171	1,244	1,725

Chemical Examination of Water from Jamaica Pond, collected near the bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6945	Jan. 24	Jan. 26	Slight.	Slight, fibrous.	0.0	-	-	.0640	.0236	.0180	.0056	-	.0320	.0007	-
7003	Feb. 11	Feb. 12	Distinct.	Cons., green.	0.0	-	-	.0880	.0294	.0194	.0100	-	.0400	.0006	-
7048	Feb. 24	Feb. 24	Slight.	Cons., fibrous.	0.0	-	-	.0464	.0234	.0174	.0060	.79	.0400	.0005	-
7182	Apr. 7	Apr 7	Slight.	Slight.	0.0	-	-	.0184	.0286	.0178	.0108	-	.0600	.0004	-
7259	Apr. 29	Apr. 29	Slight.	Cons., green.	0.0	-	-	.0488	.0240	.0190	.0050	-	.0500	.0005	-
7312	May 13	May 13	Distinct.	Cons.	0.0	-	-	.1040	.0334	.0220	.0114	-	.0200	.0049	-
7363	May 27	May 27	Decided.	Heavy, rusty.*	0.0	-	-	.1080	.0580	.0310	.0270	-	.0150	.0020	-
7429	June 10	June 10	Decided.	Cons., yellow.	0.0	-	-	.1200	.0260	.0140	.0120	.75	.0200	.0010	-
7501	June 29	June 30	Distinct, milky.	Heavy, rusty.	1.0†	-	-	.2480	.0310	.0150	.0160	-	.0150	.0005	-
7560	July 14	July 14	Distinct.	Cons., fibrous.	0.1	-	-	.1720	.0300	.0120	.0180	-	.0200	.0001	-
7757	Aug. 6	Aug. 7	Distinct.	Slight.	0.0	7.00	1.90	.1600	.0370	.0196	.0174	.85	.0090	.0002	-

Odor of 7048 very faintly vegetable; of 7429 and 7757 faintly disagreeable; of 7363, 7501 and 7560 offensive; of all others, none. There was no decided change on heating.—— The samples were collected from the north-easterly portion of the pond where the water is deepest.

* On the second day. † After standing three days.

BOSTON.

Microscopical Examination of Water from Jamaica Pond, collected near the bottom.

[Number of organisms per cubic centimeter.]

	1891.										
	Jan.	Feb.	Feb.	April.	April.	May.	May.	June.	June.	July.	Aug.
Day of examination,	27	14	26	8	30	14	28	11	30	15	7
Number of sample,	6945	7003	7048	7182	7259	7312	7363	7429	7501	7560	7757
PLANTS.											
Diatomaceæ,	**2,264**	**2,366**	**4,048**	**1,474**	**1,363**	**1,008**	**462**	**98**	**2**	**pr.**	**2**
Asterionella,	8	2	8	76	10	0	0	0	0	0	2
Melosira,	70	20	24	50	9	0	2	0	0	0	0
Synedra,	2,186	2,344	4,016	1,348	1,344	1,008	460	98	2	pr.	0
Cyanophyceæ,	**0**	**0**	**24**	**0**	**0**	**0**	**30**	**0**	**10**	**30**	**261**
Anabæna,	0	0	24	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	30	0	7	0	190
Microcystis,	0	0	0	0	0	0	0	0	3	30	71
Algæ,	**283**	**23**	**226**	**41**	**153**	**74**	**80**	**41**	**2**	**32**	**57**
Botryococcus,	0	0	0	0	0	0	0	0	0	0	6
Chlorococcus,	6	0	0	0	0	17	6	16	0	0	21
Closterium,	1	0	2	12	7	2	1	4	0	30	14
Cosmarium,	186	20	200	19	68	36	62	10	0	2	3
Protococcus,	0	0	16	7	17	0	0	0	0	0	0
Raphidium,	38	0	0	0	0	0	0	0	0	0	0
Scenedesmus,	52	1	8	3	60	17	11	10	1	pr.	1
Staurastrum,	pr.	2	0	0	1	2	0	1	1	pr.	12
Fungi,	**50**	**26**	**40**	**0**	**196**	**352**	**432**	**0**	**314**	**152**	**197**
Crenothrix,	50	26	40	0	196	352	432	0	314	152	178
Molds,	0	0	0	0	0	0	0	0	0	0	19
ANIMALS.											
Rhizopoda. Difflugia,	**0**	**0**	**0**	**2**	**9**	**1**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**pr.**	**pr.**	**0**	**4**	**3**	**2**	**0**	**0**	**0**	**2**	**60**
Ceratium,	0	0	0	0	0	0	0	0	0	2	60
Glenodinium,	0	0	0	0	2	0	0	0	0	0	pr.
Peridinium,	pr.	pr.	0	2	0	0	0	0	0	0	0
Trachelomonas,	pr.	0	0	2	1	2	0	0	0	0	pr.
Vermes,	**pr.**	**0**	**0**	**13**	**0**	**0**	**0**	**0**	**1**	**pr.**	**0**
Anurea,	pr.	0	0	0	0	0	0	0	1	pr.	0
Rotatorian ova,	0	0	0	13	0	0	0	0	0	0	0
Crustacea,	**pr.**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**0**	**pr.**	**0**	**0**	**pr.**
Bosmina,	0	0	0	0	pr.	0	0	0	0	0	0
Cyclops,	pr.	pr.	pr.	0	pr.	0	0	pr.	0	0	0
Daphnia,	pr	0	0	0	0	pr.	0	0	0	0	0
Entomostracan remains,	0	0	0	0	0	0	0	0	0	0	pr.
Miscellaneous. Zoöglœa,	**264**	**1,654**	**424**	**136**	**972**	**904**	**1,396**	**212**	**820**	**332**	**382**
TOTAL,	2,861	4,069	4,762	1,670	2,696	2,339	2,400	351	1,149	548	948

BOSTON.

Table showing the Average Monthly Heights above tide-marsh level of the Water in the Lakes and Storage Reservoirs of the Boston Water Works, from which Samples of Water were collected during the year 1891.

MONTHS.	Reservoir No. 2. Flash Boards, 167.12.	Reservoir No 3. Stone Crest, 176.24.	Reservoir No. 4. Flash Boards, 215.21.	Farm Pond. High Water, 149.25.	Lake Cochituate. High Water, 134.36.	Mystic Lake. High Water, 7.00.
January,	166.20	175.22	213.85	149.48	132.95	4.75
February,	166.06	174.41	210.14	149.53	132.73	4.56
March,	165.57	172.73	210.35	149.50	133.13	4.79
April,	166.12	175.59	214.25	149.33	134.23	5.81
May,	166.59	175.30	214.50	149.32	133.56	6.71
June,	165.36	175.37	214.84	149.17	132.68	6.58
July,	162.79	175.30	214.07	148.96	131.44	5.62
August,	158.86	175.00	208.92	148.83	130.04	3.67
September,	160.47	173.17	204.72	148.94	129.02	2.29
October,	158.51	169.84	203.35	148.81	127.67	0.20
November,	158.64	164.60	204.41	148.75	126.71	—0.30
December,	162.15	164.03	206.51	148.84	126.72	+0.68

WATER SUPPLY OF BRADFORD. — BRADFORD WATER COMPANY.

The works were built in 1890, but, as the supply obtained from them was somewhat limited, three new wells were added in 1891, making eleven in all connected with the works. There are now nine wells in a line about 1,200 feet long on the southerly shore of Porter's Island in the Merrimack River, one well near the middle of the island and one on the south bank of the river, opposite the island. Of the new wells, two are located at the north end of the line of wells already mentioned, 100 feet apart and 100 feet from the nearest of the original wells. The well at the end of the line is 24 feet long, 12 feet wide and 18 feet deep; the other one is 24 feet square and 18 feet deep. The third new well, which is the one near the middle of the island, is 23 feet square and 22 feet deep. All of these wells have wooden curbs.

BRADFORD.

Chemical Examination of Water from the Wells of the Bradford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7248	Apr. 27	Apr. 29	Distinct.	Slight.	0.05	6.10	.0000	.0054	.24	.0300	.0001	1.7
7249	Apr. 27	Apr. 29	V. slight.	None.	0.03	4.70	.0000	.0000	.22	.0400	.0000	1.8

Odor of No. 7248, vegetable and somewhat disagreeable, disappears when heated; of No. 7249, none. ——Sample No. 7248 was collected from Well No. 5, which is the third from the southerly end of the line of wells on the island. No. 7249 was collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No. 7248. Diatomaceæ, *Melosira*, 5; *Navicula*, pr. Miscellaneous, *Zoöglœa*, 148. Total, 153.
No. 7249. Diatomaceæ, *Melosira*, 3. Miscellaneous, *Zoöglœa*, 178. Total, 181.

Water Supply of Braintree.

The Braintree Water Supply Company's works were purchased by the town of Braintree in 1891.

Water Supply of Bridgewater and East Bridgewater. — The Bridgewaters Water Company.

Description of Works. — The sources of supply are four wells located on the east bank of the Town River in Bridgewater. The largest well is oval in shape, 45 feet in length and 18 feet in width inside. It is 17 feet in depth below the ground in its immediate vicinity, and its bottom is about on a level with the surface of the water in the river at its average stage. The second well is on the down stream side of the first, and is circular, 18 feet in diameter and 18 feet deep below the level of the ground about it. Its bottom is about one foot below the average level of water in the river. The distance between the first and second wells is 16 feet. These were the first wells constructed, and as they furnished only a limited supply a third well was dug about 80 feet farther down stream and in lower ground than the second. It is 10 feet in diameter and 27 feet deep, the bottom being about 14.5 feet below the average level of water in the river. In the bottom of this well a 6-inch tubular well extends to a farther depth of 86.5 feet.

The first well is distant about 200 feet from the river and the third well 134 feet. To still further increase the supply a fourth well was added, which is situated about 36 feet up stream from the large well first described. This well is tubular, 6 inches in diameter and 202 feet in depth.

Water is also drawn into the large well from a spring 1,400 feet distant.

There is a direct connection with the river, for use in cases of emergency, but to avoid using river water a small reservoir is now being constructed which will intercept the water from several large springs which flow into the river several hundred feet up stream from the wells and on the same side of the river.

Chemical Examination of Water from the Town River at Bridgewater.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended		Nitrates.	Nitrites.	
	1891.														
8281	Dec. 1	Dec. 2	Slight.	Slight.	1.50	6.05	2.50	.0004	.0316	.0280	.0036	.62	.0100	.0001	1.4

Odor, vegetable.——The sample was collected from the Town River opposite the wells of the Bridgewaters Water Company.

Microscopical Examination.

Diatomaceæ, *Asterionella*, pr.; *Diatoma*, 7; *Fragilaria*, 3; *Grammatophora*, 12; *Meridion*, pr.; *Synedra*, 69; *Tabellaria*, 5. Algæ, *Chlorococcus*, pr. Fungi, *Crenothrix*, 11; *Molds*, pr. Miscellaneous *Zoöglœa*, 41. Total, 148.

Water Supply of Brockton.

In 1891 to increase the pressure in the city a pumping station and iron tank were constructed on the line of the main pipe about 3,500 feet from the storage reservoir. All of the water is now pumped to the tank which is 62 feet in diameter and 59 feet 4 inches in height, and open at the top.

The water supply has not been so seriously affected by disagreeable tastes and odors during the past two seasons as it was during previous years.

BROCKTON.

Chemical Examination of Water from Salisbury Brook at the point where it enters the Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7018	Feb. 16	Feb. 17	None.	V. slight.	0.65	2.70	1.10	.0000	.0108	.0094	.0014	.22	.0070	.0001	0.6
7128	Mar. 16	Mar. 17	V. slight.	Slight.	0.45	2.90	1.10	.0000	.0106	.0086	.0020	.16	.0080	.0000	0.6
7230	Apr. 20	Apr. 21	V. slight.	V. slight.	1.50	4.00	2.30	.0000	.0234	.0224	.0010	.23	.0100	.0001	0.6
7323	May 18	May 19	V. slight.	V. slight.	1.60	5.05	3.05	.0000	.0366	.0342	.0024	.23	.0030	.0000	0.9
7453	June 15	June 16	Slight.	Cons.	1.70	5.80	3.25	.0012	.0346	.0308	.0038	.16	.0070	.0000	1.3
7920	Sept. 14	Sept. 15	None.	V. slight.	2.70	7.60	4.35	.0008	.0470	.0424	.0046	.30	.0000	.0000	1.4
8038	Oct. 12	Oct. 13	V. slight.	None.	1.50	7.25	3.50	.0006	.0442	.0378	.0064	.52	.0000	.0007	1.3
8241	Nov. 9	Nov. 10	None.	None.	1.30	5.75	2.85	.0000	.0266	.0248	.0018	.57	.0000	.0000	0.9
8331	Dec. 14	Dec. 15	None.	None.	1.40	4.70	2.20	.0000	.0144	.0138	.0006	.40	.0080	.0001	0.8
Av.	....	....	....	....	1.42	5.08	2.63	.0003	.0276	.0249	.0027	.33	.0048	.0001	0.9

Odor, distinctly vegetable. —— The samples were collected from the brook just above the reservoir.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Feb.	Mar.	Apr.	May.	June.	Sept.	Oct.	Nov.	Dec.
Day of examination,	18	18	21	19	18	15	13	11	16
Number of sample,	7018	7128	7230	7323	7453	7920	8038	8241	8331
PLANTS.									
Diatomaceæ,	0	18	12	29	3	7	10	5	pr.
Fragilaria,	0	11	0	0	0	0	0	0	0
Melosira,	0	6	0	5	0	1	9	2	0
Synedra,	0	1	12	21	3	6	pr.	2	pr.
Tabellaria,	0	0	0	3	0	pr.	1	1	pr.
Algæ,	0	14	4	11	2	1	pr.	0	0
Chlorococcus,	0	10	0	0	2	0	0	0	0
Conferva,	0	4	4	1	0	1	pr.	0	0
Staurastrum,	0	0	0	10	0	0	0	0	0
Fungi. Crenothrix,	0	0	0	1	17	0	0	1	0

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.								
	Feb.	Mar.	Apr.	May.	June.	Sept.	Oct.	Nov.	Dec.
ANIMALS.									
Infusoria,	**0**	**2**	**7**	**13**	**pr.**	**0**	**0**	**pr.**	**0**
Dinobryon,	0	0	6	12	0	0	0	0	0
Peridinium,	0	2	1	1	pr.	0	0	pr.	0
Miscellaneous. Zoöglœa,	**0**	**5**	**32**	**6**	**21**	**3**	**1**	**10**	**0**
TOTAL,	0	39	55	60	43	11	11	16	pr.

Chemical Examination of Water from Salisbury Brook Storage Reservoir, collected one foot beneath the surface.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6919	Jan. 18	Jan. 20	Slight.	V. slight.	0.75	3.65	1.30	.0042	.0172	.0150	.0022	.30	.0050	.0000	0.9
7019	Feb. 16	Feb. 17	None.	V. slight.	0.50	3.00	1.05	.0010	.0112	.0074	.0038	.21	.0080	.0001	0.6
7129	Mar. 16	Mar. 17	Slight.	V. slight.	0.35	2.55	0.85	.0000	.0114	.0084	.0030	.19	.0080	.0000	0.6
7231	Apr. 20	Apr. 21	Slight.	Slight.	0.40	2.75	1.55	.0000	.0158	.0104	.0054	.25	.0070	.0000	0.5
7325	May 18	May 19	Distinct.	Cons., green.	0.60	2.95	1.45	.0000	.0266	.0180	.0086	.24	.0020	.0000	0.5
7452	June 15	June 16	Slight.	Cons.	0.60	3.05	1.50	.0006	.0236	.0190	.0046	.21	.0050	.0000	0.5
7577	July 20	July 21	Slight.	Cons.	0.60	3.00	1.95	.0014	.0250	.0212	.0038	.27	.0090	.0000	0.2
7650	Aug. 24	Aug. 25	Distinct.	Slight, green.	0.60	3.35	1.70	.0006	.0266	.0208	.0058	.31	.0020	.0001	0.6
7921	Sept. 14	Sept. 15	Distinct.	Cons.	0.65	3.15	1.60	.0000	.0276	.0234	.0042	.30	.0000	.0000	0.6
8080	Oct. 12	Oct. 13	Slight.	Cons., green	0.75	3.25	1.75	.0038	.0256	.0224	.0032	.31	.0070	.0007	0.6
8242	Nov. 9	Nov. 10	Slight.	Slight.	0.75	3.55	1.35	.0002	.0280	.0226	.0054	.38	.0120	.0000	0.5
8332	Dec. 14	Dec. 15	Slight.	V. slight	0.90	3.60	1.40	.0000	.0164	.0138	.0026	.39	.0080	.0002	0.6
Av.	....	....	....	....	0.62	3.15	1.45	.0010	.0213	.0169	.0044	.28	.0061	.0001	0.6

Odor, generally faintly vegetable, sometimes mouldy. Nos. 7231, 7825 and 7452 became disagreeable on heating, the last being strongly so. —— The samples were collected from the reservoir near the dam, one foot beneath the surface.

The reservoir was full at the beginning of the year and remained so until June, when it began to lower, reaching the lowest point, 21 inches below the crest of the overflow, in August. It was full again early in November.

BROCKTON.

Microscopical Examination of Water from Salisbury Brook Storage Reservoir, collected one foot beneath the surface.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	18	18	22	19	18	22	25	15	13	11	16
Number of sample,	6919	7019	7129	7231	7325	7452	7577	7850	7921	8039	8242	8332
PLANTS.												
Diatomaceæ,	3	8	18	162	296	118	339	287	1,112	259	532	144
Asterionella,	2	4	10	27	76	38	11	22	16	9	86	59
Cyclotella,	0	0	0	0	0	0	5	0	0	1	5	0
Diatoma,	0	0	0	0	0	2	2	4	63	8	4	pr.
Fragilaria,	0	0	0	0	0	0	0	0	0	0	9	4
Melosira,	0	1	1	53	136	1	16	3	24	80	28	9
Synedra,	pr.	3	1	46	2	5	1	0	27	21	136	31
Tabellaria,	1	0	6	36	82	72	304	258	982	140	264	41
Cyanophyceæ,	0	0	0	6	pr.	0	17	49	11	0	4	4
Anabæna,	0	0	0	0	0	0	0	33	0	0	0	0
Chroöcoccus,	0	0	0	6	0	0	0	9	0	0	4	4
Clathrocystis,	0	0	0	0	pr.	0	0	7	11	0	0	0
Nostoc,	0	0	0	0	0	0	17	0	0	0	0	0
Algæ,	0	10	pr.	1	3	16	68	43	134	41	16	1
Chlorococcus,	0	10	0	0	2	4	51	34	3	0	8	0
Conferva,	0	0	pr.	pr.	0	10	0	0	0	0	0	pr.
Eudorina,	0	0	0	0	0	0	0	0	1	6	0	0
Pandorina,	0	0	0	0	0	0	0	4	11	1	0	0
Raphidium,	0	0	0	0	0	0	10	0	24	26	0	0
Scenedesmus,	0	0	0	1	1	2	2	3	8	5	pr.	1
Staurastrum,	0	0	0	0	pr.	0	5	2	86	3	0	0
Staurogenia,	0	0	0	0	0	0	0	0	1	0	13	0
Fungi. Crenothrix,	2	0	0	1	0	0	0	0	9	pr.	pr.	1
ANIMALS.												
Rhizopoda,	0	0	0	pr.	0	0	0	0	2	1	pr.	pr.
Actinophrys,	0	0	0	0	0	0	0	0	2	pr.	pr.	pr.
Difflugia,	0	0	0	pr.	0	0	0	0	pr.	1	0	pr.
Infusoria,	15	10	53	17	1	3	9	15	8	1	7	1
Dinobryon,	14	2	45	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	12	0	0	4	0	0	0	0	0
Monas,	0	0	7	0	0	0	0	pr.	3	pr.	1	0
Peridinium,	1	8	1	5	0	0	0	13	2	pr.	1	1
Trachelomonas,	0	0	0	0	1	3	5	2	3	1	5	pr.
Vermes,	2	0	0	pr.	0	pr.	2	5	3	1	1	0
Anuræa,	2	0	0	pr.	0	pr.	1	3	2	1	0	0
Polyarthra,	0	0	0	0	0	0	1	2	1	0	1	0
Crustacea,	0	0	0	0	0	0	pr.	pr.	pr.	pr.	0	0
Bosmina,	0	0	0	0	0	0	pr.	0	0	0	0	0
Cyclops,	0	0	0	0	0	0	0	pr.	pr.	pr.	0	0
Miscellaneous. Zoöglœa,	4	5	128	200	168	122	210	70	210	96	114	36
TOTAL,	26	33	199	387	488	259	645	469	1,489	399	674	187

BROCKTON.

Chemical Examination of Water from Salisbury Brook Storage Reservoir, collected near the bottom.

[Parts per 100,000.]

Number.	Date of: Collection.	Date of: Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as: Nitrates.	Nitrogen as: Nitrites.	Hardness.
	1891.														
6920	Jan. 18	Jan. 20	Slight.	V. slight.	0.75	3.75	1.30	.0048	.0158	.0150	.0008	.30	.0050	.0000	0.9
7020	Feb. 16	Feb. 17	None.	V. slight.	0.45	2.90	1.25	.0012	.0124	.0100	.0024	.18	.0070	.0001	0.5
7130	Mar. 16	Mar. 17	V. slight.	Slight.	0.40	2.85	1.05	.0002	.0118	.0092	.0026	.19	.0080	.0000	0.6
7232	Apr. 20	Apr. 21	Slight.	Slight.	0.40	2.45	0.95	.0000	.0132	.0086	.0046	.24	.0070	.0000	0.5
7324	May 18	May 19	Distinct.	Cons., green.	0.60	2.75	1.45	.0000	.0216	.0146	.0070	.26	.0020	.0000	0.5
7454	June 15	June 16	Slight.	Cons.	0.55	3.05	1.75	.0002	.0238	.0178	.0060	.24	.0050	.0000	0.3
7578	July 20	July 21	Slight.	Cons.	0.60	3.05	1.30	.0020	.0254	.0214	.0040	.26	.0120	.0000	0.3
7851	Aug. 24	Aug. 25	Distinct.	Slight.	0.65	3.10	1.35	.0020	.0244	.0210	.0034	.33	.0000	.0001	0.6
7922	Sept. 14	Sept. 15	Distinct.	Cons.	0.75	3.25	1.60	.0000	.0288	.0224	.0064	.29	.0000	.0000	0.6
8040	Oct 12	Oct. 13	Slight.	Cons., green.	0.65	3.05	1.50	.0022	.0314	.0254	.0060	.30	.0100	.0007	0.6
8243	Nov. 9	Nov. 10	Slight.	Slight, green.	0.75	3.55	1.75	.0000	.0254	.0224	.0030	.38	.0100	.0000	0.3
8333	Dec 14	Dec. 15	Slight.	V. slight.	1.10	3.65	1.80	.0006	.0168	.0148	.0020	.40	.0150	.0002	0.5
Av..	....	....	....	....	0.64	3.12	1.42	.0011	.0209	.0169	.0040	.28	.0067	.0001	0.5

Odor, generally vegetable, frequently none. On heating, Nos. 7232, 7324 and 7454 became disagreeable, the last being very disagreeable. —— The samples were collected from the reservoir, near the dam, at a depth of about 12 feet beneath the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	18	18	22	19	18	22	25	15	13	11	16
Number of sample,	6920	7020	7130	7232	7324	7454	7578	7851	7922	8040	8243	8333
PLANTS.												
Diatomaceæ,	**2**	**11**	**20**	**145**	**705**	**100**	**421**	**237**	**1,491**	**292**	**571**	**209**
Asterionella,	1	2	7	27	126	46	52	14	26	9	108	102
Cyclotella,	0	0	0	0	0	0	21	0	pr.	pr.	1	pr.
Diatoma,	0	0	0	0	10	4	8	0	92	8	2	2
Fragilaria,	0	0	0	0	3	0	0	6	0	4	0	0
Melosira,	0	0	3	40	394	0	72	5	56	128	25	26
Navicula,	pr.	0	pr.	0	2	0	pr.	0	1	1	1	1
Synedra.	1	3	2	56	4	2	pr.	0	34	10	188	41
Tabellaria,	0	6	8	22	166	48	268	212	1,282	132	246	37

BROCKTON.

Microscopical Examination of Water from Salisbury Brook Storage Reservoir, collected near the bottom — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Cyanophyceæ,	0	0	0	0	pr	0	38	35	41	0	6	3
Anabæna,	0	0	0	0	0	0	0	31	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	38	0	5	0	6	3
Clathrocystis,	0	0	0	0	pr.	0	0	4	36	0	0	0
Algæ,	0	7	pr.	7	7	10	99	26	98	33	13	1
Chlorococcus,	0	7	pr.	0	2	5	53	17	21	14	1	1
Conferva,	0	0	0	2	0	5	0	0	0	0	0	0
Pandorina,	0	0	0	0	pr.	0	17	0	17	0	0	0
Pediastrum,	0	0	0	0	pr.	pr.	pr.	0	3	3	pr.	0
Raphidium,	0	0	0	0	0	0	23	0	24	8	8	0
Scenedesmus,	0	0	0	5	5	0	3	3	11	5	2	pr.
Staurastrum,	0	0	0	0	0	pr.	3	6	12	1	0	0
Staurogenia,	0	0	0	0	0	0	0	0	8	2	2	0
Fungi. Crenothrix,	0	0	1	2	0	pr.	0	0	1	0	1	pr.
ANIMALS.												
Rhizopoda. Actinophrys,	0	0	0	0	pr.	0	1	1	1	0	0	0
Infusoria,	7	4	14	6	1	1	13	26	5	10	3	pr.
Dinobryon,	0	pr.	13	0	0	0	0	0	0	0	0	0
Dinobryon cases,	6	0	0	0	0	0	0	0	0	0	0	pr.
Euglena,	0	0	0	0	0	0	0	0	0	3	0	0
Monas,	0	0	pr.	0	pr.	pr.	pr.	0	2	0	pr.	0
Peridinium,	1	4	1	6	0	0	0	24	1	5	pr.	pr.
Trachelomonas,	pr.	0	0	0	1	1	13	2	2	2	3	pr.
Vermes,	0	0	0	1	pr.	0	1	3	pr.	pr.	2	pr.
Anuræa,	0	0	0	1	pr.	0	1	3	pr.	pr.	1	0
Polyarthra,	0	0	0	pr.	0	0	0	pr.	0	pr.	1	pr.
Crustacea,	0	0	0	0	0	0	pr.	pr.	pr.	pr.	0	0
Bosmina,	0	0	0	0	0	0	pr.	0	pr.	0	0	0
Cyclops,	0	0	0	0	0	0	0	pr.	pr.	pr.	0	0
Miscellaneous. Zoöglœa,	5	1	236	218	416	96	580	122	772	104	150	38
TOTAL,	14	23	271	379	1,129	207	1,155	450	2,407	439	746	251

BROCKTON.

Chemical Examination of Samples from the Brockton Drains.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Color.	Residue on Evaporation. Total. Unfilter'd.	Residue on Evaporation. Total. Filtered.	Residue on Evaporation. Loss on Ignition. Unfilter'd.	Residue on Evaporation. Loss on Ignition. Filtered.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
7984	Sept. 30	Oct. 2	0.70	45.90	44.10	12.40	-	3.0200	.1990	.1660	.0330	10.11	.3250	.0280	-
7985	Sept. 30	Oct. 2	0.30	77.70	68.50	20.00	11.80	1.3300	.4330	.2420	.1910	29.30	.0000	.0000	-
7986	Sept. 30	Oct. 2	Deep purple.	40.00	30.90	14.00	10.10	.4300	.1480	.0610	.0870	2.52	.2500	.0060	-
8014	Oct. 5	Oct. 6	0.50	24.20	17.20	10.30	4.20	.2480	.1590	.0360	.1230	2.10	.1250	.6250	-

All the samples had a decided turbidity, a heavy sediment and an offensive odor. No. 7984 was collected from the Montello Street drain at the corner of Crescent Street; No. 7985 from the Centre Street drain at the corner of Montello Street. Nos. 7986 and 8014 were collected from the North Main Street drain at corner of North Montello Street, and a private way under the main line of the O. C. R.R., between Charles and Rosseter streets.

Chemical Examination of Water from the Salisbury Plain River, below Brockton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
7983	Sept. 30	Oct. 2	Distinct.	Slight.	0.70	9.65	2.80	.0104	.0188	.0168	.0020	1.75	.1100	.0045	2.6

Odor, decidedly vegetable and mouldy, becoming disagreeable on heating.——The sample was collected from the river at "Cart Bridge road" near the boundary between Brockton and West Bridgewater. This stream receives the drainage of the city of Brockton.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 1; *Navicula*, pr. Fungi, *Crenothrix*, 55. Infusoria, *Euglena*, 1; *Monas*, pr.; *Peridinium*, 1; *Synura*, 1, Crustacea, *Cyclops*, pr. Miscellaneous, *Zoöglœa*, 27. Total, 87.

Water Supply of Brookline.

Works for an additional supply for the town were built in 1890 and 1891. They consist of 44 two and one-half inch tubular wells sunk in the low land on both sides of Charles River, not far from the present filter-galleries at Cow Bay, West Roxbury. The wells vary in depth from 16 feet to 67 feet, averaging 35 feet. Of the 44 wells, 20 are on the right or east bank of the river, the first one being located within 200 feet of the pumping station. They are connected

BROOKLINE.

with a cast-iron pipe 24 inches in diameter, which runs from the pumping station in a general direction a little south of west, for a distance of about 2,500 feet. Of this distance about 1,250 feet are on the right or east bank of the river, while about 1,000 feet are on the left or west bank, the river being at this point about 250 feet in width. The wells are driven on both sides of the twenty-four inch pipe at distances of from 5 to 10 feet from the pipe, and 15 to 50 feet from each other on the same side of the pipe.

During 1891 water flowed by gravity from the new system into the pump-well at the pumping station in sufficient quantity to furnish, in addition to the water from the filter-galleries, all the water required by the town. Water will be pumped, however, from the new system into the pump-well at the pumping station whenever the natural flow from the wells is not enough to make up for the deficiency in the supply from the filter-galleries.

Water Supply of Cambridge.

Chemical Examination of Water from Fresh Pond, in Cambridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6868	Jan. 5	Jan. 5	V. slight.	Slight, green.	0.40	7.70	1.35	.0156	.0240	.0180	.0060	.78	.0580	.0005	4.2
6970	Feb. 3	Feb. 3	Slight.	Slight.	0.25	8.00	2.60	.0162	.0192	.0160	.0032	.77	.0350	.0007	4.0
7080	Mar. 3	Mar. 3	Slight.	Cons., green.	0 30	8.00	2.00	.0132	.0198	.0152	.0046	.74	.0400	.0005	3.8
7187	Apr. 6	Apr. 8	Distinct.	Cons., green.	0.20	7.95	1.75	.0080	.0216	.0168	.0048	.74	.0550	.0005	3.8
7271	May 5	May 5	Slight.	Cons., green	0.10	7.40	1.40	.0000	.0238	.0144	.0094	.73	.0500	.0003	4.0
7381	June 2	June 4	Distinct.	Cons.	0.10	7.80	1.65	.0060	.0208	.0172	.0036	.74	.0500	.0007	3.5
7535	July 7	July 7	Distinct.	Cons.	0.10	8.05	1.75	.0004	.0262	.0168	.0094	.69	.0350	.0005	3.6
7759	Aug. 10	Aug. 11	Distinct.	Cons.	0.03	7.95	2.00	.0016	.0216	.0154	.0062	.81	.0400	.0003	3.9
7897	Sept. 2	Sept. 3	Slight.	Slight, green.	0.00	8.25	1.85	.0008	.0248	.0196	.0052	.74	.0150	.0003	4.2
8013	Oct. 6	Oct. 6	Distinct.	Slight.	0.10	7.65	1.75	.0002	.0276	.0176	.0100	.71	.0030	.0000	3.0
8196	Nov. 3	Nov. 4	Distinct.	Cons., green.	0.10	7.90	1.80	.0342	.0198	.0132	.0066	.75	.0070	.0005	3.8
8286	Dec. 3	Dec. 4	Slight.	Cons., green.	0.10	8.60	1.75	.0174	.0332	.0150	.0182	.75	.0120	.0005	3.9
Av.	....	....	....	....	0.15	7.94	1.80	.0095	.0235	.0162	.0073	.75	.0333	.0004	3.8

Odor, generally none, frequently vegetable; when heated, generally faintly vegetable, frequently distinctly vegetable.——The samples were collected from the pump-well at the pumping station.

CAMBRIDGE.

Microscopical Examination of Water from Fresh Pond, in Cambridge.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	4	5	9	12	3	7	10	4	7	4	4
Number of sample,	6868	6970	7080	7187	7271	7381	7535	7759	7897	8013	8196	8236
PLANTS.												
Diatomaceæ,	**1,009**	**340**	**2,276**	**1,197**	**1,925**	**22**	**385**	**73**	**44**	**25**	**284**	**4,910**
Asterionella,	216	46	5	54	0	8	236	7	0	1	24	528
Cyclotella,	0	0	0	690	28	0	0	3	0	0	0	22
Diatoma,	0	0	0	1	1	1	pr.	0	0	2	9	0
Fragilaria,	0	0	0	11	0	0	0	59	34	9	0	26
Melosira,	43	0	64	148	19	0	5	0	3	3	178	2,928
Nitzschia,	0	6	3	7	138	0	30	0	0	0	9	0
Stephanodiscus,	456	76	1,992	130	5	11	54	0	pr.	pr.	35	1,248
Synedra,	22	22	28	96	1,644	2	50	2	5	2	3	22
Tabellaria,	272	190	184	60	90	0	10	2	2	8	26	136
Cyanophyceæ,	**18**	**0**	**0**	**0**	**250**	**4**	**43**	**485**	**976**	**1,084**	**78**	**44**
Chroöcoccus,	0	0	0	0	250	4	4	44	10	98	0	0
Clathrocystis,	18	0	0	0	pr.	0	7	6	5	3	3	6
Cœlosphærium,	0	0	0	0	0	0	4	17	23	15	0	0
Microcystis,	0	0	0	0	0	0	28	418	938	968	75	38
Algæ,	**11**	**334**	**0**	**6**	**18**	**32**	**11**	**16**	**20**	**99**	**41**	**189**
Chlorococcus,	0	334	0	0	0	0	7	15	18	1	2	8
Closterium,	0	pr.	0	0	0	23	pr.	pr.	0	96	pr.	176
Protococcus,	0	0	0	6	0	0	0	0	0	0	19	0
Raphidium,	0	0	0	0	0	8	1	0	2	0	18	1
Scenedesmus,	11	pr.	0	pr.	18	0	0	0	pr.	0	1	3
Staurastrum,	pr.	0	0	0	0	1	8	1	pr.	2	1	1
Fungi. Crenothrix,	**1**	**4**	**88**	**1**	**0**	**0**	**0**	**0**	**0**	**pr.**	**13**	**26**
ANIMALS.												
Infusoria,	**pr.**	**pr.**	**pr.**	**3**	**4**	**6**	**3**	**7**	**2**	**13**	**pr.**	**8**
Ceratium,	0	0	0	0	0	0	1	3	1	5	0	0
Dinobryon,	pr.	0	0	0	2	0	0	0	0	0	0	0
Monas,	0	pr.	0	0	0	0	0	0	0	pr.	pr.	5
Peridinium,	0	0	0	0	1	2	pr.	3	0	0	0	0
Trachelomonas,	0	pr.	pr.	3	1	4	2	1	1	1	pr.	1
Vorticella,	0	0	0	0	0	0	0	0	0	7	0	2
Vermes,	**0**	**pr.**	**1**	**0**	**0**	**0**	**1**	**pr.**	**0**	**pr.**	**1**	**4**
Anurea,	0	pr.	0	0	0	0	0	pr.	0	pr.	1	4
Rotatorian ova,	0	0	1	0	0	0	1	0	0	0	0	0
Crustacea,	**0**	**0**	**0**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**0**	**0**	**pr.**	**pr.**
Bosmina,	0	0	0	0	pr.	0	0	pr.	0	0	0	0
Cyclops,	0	0	0	pr.	0	0	pr.	pr.	0	0	pr.	pr.
Miscellaneous. Zoöglœa,	**0**	**0**	**164**	**164**	**544**	**62**	**194**	**202**	**250**	**228**	**392**	**124**
TOTAL,	1,039	678	2,529	1,391	2,741	126	637	783	1,292	1,449	809	5,305

BROOKLINE.

with a cast-iron pipe 24 inches in diameter, which runs from the pumping station in a general direction a little south of west, for a distance of about 2,500 feet. Of this distance about 1,250 feet are on the right or east bank of the river, while about 1,000 feet are on the left or west bank, the river being at this point about 250 feet in width. The wells are driven on both sides of the twenty-four inch pipe at distances of from 5 to 10 feet from the pipe, and 15 to 50 feet from each other on the same side of the pipe.

During 1891 water flowed by gravity from the new system into the pump-well at the pumping station in sufficient quantity to furnish, in addition to the water from the filter-galleries, all the water required by the town. Water will be pumped, however, from the new system into the pump-well at the pumping station whenever the natural flow from the wells is not enough to make up for the deficiency in the supply from the filter-galleries.

Water Supply of Cambridge.

Chemical Examination of Water from Fresh Pond, in Cambridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6868	Jan. 5	Jan. 5	V. slight.	Slight, green.	0.40	7.70	1.35	.0156	.0240	.0180	.0060	.78	.0580	.0005	4.2
6970	Feb. 3	Feb. 3	Slight.	Slight.	0.25	8.00	2.60	.0162	.0192	.0160	.0032	.77	.0350	.0007	4.0
7080	Mar. 3	Mar. 3	Slight.	Cons., green.	0.30	8.00	2.00	.0132	.0198	.0152	.0046	.74	.0400	.0005	3.8
7187	Apr. 6	Apr. 8	Distinct.	Cons., green.	0.20	7.95	1.75	.0080	.0216	.0168	.0048	.74	.0550	.0005	3.8
7271	May 5	May 5	Slight.	Cons., green	0.10	7.40	1.40	.0000	.0238	.0144	.0094	.73	.0500	.0003	4.0
7381	June 2	June 4	Distinct.	Cons.	0.10	7.80	1.65	.0060	.0208	.0172	.0036	.74	.0500	.0007	3.5
7535	July 7	July 7	Distinct.	Cons.	0.10	8.05	1.75	.0004	.0262	.0168	.0094	.69	.0350	.0005	3.6
7759	Aug. 10	Aug. 11	Distinct.	Cons.	0.03	7.95	2.00	.0016	.0216	.0154	.0062	.81	.0400	.0003	3.9
7897	Sept. 2	Sept. 3	Slight.	Slight, green.	0.00	8.25	1.85	.0008	.0248	.0196	.0052	.74	.0150	.0003	4.2
8013	Oct. 6	Oct. 6	Distinct.	Slight.	0.10	7.65	1.75	.0002	.0276	.0176	.0100	.71	.0030	.0000	3.0
8196	Nov. 3	Nov. 4	Distinct.	Cons., green.	0.10	7.90	1.80	.0342	.0198	.0132	.0066	.75	.0070	.0005	3.8
8286	Dec. 3	Dec. 4	Slight.	Cons., green.	0.10	8.60	1.75	.0174	.0332	.0150	.0182	.75	.0120	.0005	3.9
Av.	....	....	....	....	0.15	7.94	1.80	.0095	.0235	.0162	.0073	.75	.0333	.0004	3.8

Odor, generally none, frequently vegetable; when heated, generally faintly vegetable, frequently distinctly vegetable.—The samples were collected from the pump-well at the pumping station.

CAMBRIDGE.

Microscopical Examination of Water from Fresh Pond, in Cambridge.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	4	5	9	12	3	7	10	4	7	4	4
Number of sample,	6868	6970	7080	7187	7271	7381	7535	7759	7897	8013	8196	8286
PLANTS.												
Diatomaceæ,	1,009	340	2,278	1,197	1,925	22	385	73	44	25	264	4,910
Asterionella,	216	46	5	54	0	8	236	7	0	1	24	528
Cyclotella,	0	0	0	690	28	0	0	3	0	0	0	22
Diatoma,	0	0	0	1	1	1	pr.	0	0	2	9	0
Fragilaria,	0	0	0	11	0	0	0	59	34	9	0	26
Melosira,	43	0	64	148	19	0	5	0	3	3	178	2,928
Nitzschia,	0	6	3	7	138	0	30	0	0	0	9	0
Stephanodiscus,	456	76	1,992	130	5	11	54	0	pr.	pr.	85	1,248
Synedra,	22	22	28	96	1,644	2	50	2	5	2	3	22
Tabellaria,	272	190	184	60	90	0	10	2	2	8	26	136
Cyanophyceæ,	18	0	0	0	250	4	43	485	976	1,084	78	44
Chroöcoccus,	0	0	0	0	250	4	4	44	10	98	0	0
Clathrocystis,	18	0	0	0	pr.	0	7	6	5	3	3	6
Cœlosphærium,	0	0	0	0	0	0	4	17	23	15	0	0
Microcystis,	0	0	0	0	0	0	28	418	938	968	75	38
Algæ,	11	334	0	6	18	32	11	16	20	99	41	189
Chlorococcus,	0	334	0	0	0	0	7	15	18	1	2	8
Closterium,	0	pr.	0	0	0	23	pr.	pr.	0	96	pr.	176
Protococcus,	0	0	0	6	0	0	0	0	0	0	19	0
Raphidium,	0	0	0	0	0	8	1	0	2	0	18	1
Scenedesmus,	11	pr.	0	pr.	18	0	0	0	pr.	0	1	3
Staurastrum,	pr.	0	0	0	0	1	8	1	pr.	2	1	1
Fungi. Crenothrix,	1	4	88	1	0	0	0	0	0	pr.	13	26
ANIMALS.												
Infusoria,	pr.	pr.	pr.	3	4	6	3	7	2	13	pr.	8
Ceratium,	0	0	0	0	0	0	1	3	1	5	0	0
Dinobryon,	pr.	0	0	0	2	0	0	0	0	0	0	0
Monas,	0	pr.	0	0	0	0	0	0	0	pr.	pr.	5
Peridinium,	0	0	0	0	1	2	pr.	3	0	0	0	0
Trachelomonas,	0	pr.	pr.	3	1	4	2	1	1	1	pr.	1
Vorticella,	0	0	0	0	0	0	0	0	0	7	0	2
Vermes,	0	pr.	1	0	0	0	1	pr.	0	pr.	1	4
Anurea,	0	pr.	0	0	0	0	0	pr.	0	pr.	1	4
Rotatorian ova,	0	0	1	0	0	0	1	0	0	0	0	0
Crustacea,	0	0	0	pr.	pr.	0	pr.	pr.	0	0	pr.	pr.
Bosmina,	0	0	0	0	pr.	0	0	pr.	0	0	0	0
Cyclops,	0	0	0	pr.	0	0	pr.	pr.	0	0	pr.	pr.
Miscellaneous. Zoöglœa,	0	0	164	184	544	62	194	202	250	228	392	124
TOTAL,	1,039	678	2,529	1,391	2,741	126	637	783	1,292	1,449	809	5,305

CAMBRIDGE.

Chemical Examination of Water from Stony Brook, where it enters the Storage Reservoir of the Cambridge Water Works, in Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6978	Feb. 3	Feb. 4	V.slight.	Slight.	0.80	4.75	1.20	.0008	.0182	.0162	.0020	.20	.0350	.0001	1.4
7086	Mar. 3	Mar. 4	V.slight.	Slight.	0.50	4.30	1.50	.0010	.0126	.0118	.0008	.32	.0050	.0000	2.1
7189	Apr. 6	Apr. 8	V.slight.	V.slight.	0.70	4.35	1.10	.0000	.0170	.0152	.0018	.34	.0150	.0001	1.6
7285	May 5	May 6	Slight.	Slight.	0.70	4.95	1.60	.0014	.0182	.0160	.0022	.38	.0300	.0001	2.1
7384	June 2	June 4	Slight.	Cons.	0.60	5.50	2.15	.0024	.0218	.0198	.0020	.36	.0150	.0005	1.9
7533	July 6	July 7	V.slight.	Slight.	0.43	5.65	1.50	.0028	.0162	.0148	.0014	.30	.0350	.0002	1.9
7760	Aug.10	Aug.11	V.slight.	Slight.	0.30	4.95	1.00	.0006	.0158	.0138	.0020	.48	.0200	.0001	2.2
7890	Sept. 2	Sept. 3	None.	V.slight.	0.80	7.10	2.60	.0024	.0292	.0268	.0024	.39	.0150	.0001	2.3
8020	Oct. 6	Oct. 7	V.slight.	Cons.	0.30	5.85	1.55	.0002	.0154	.0134	.0020	.45	.0200	.0001	2.2
8197	Nov. 3	Nov. 4	V.slight.	V.slight.	0.75	6.70	2.15	.0002	.0204	.0190	.0014	.49	.0250	.0002	2.5
8298	Dec. 3	Dec. 4	V.slight.	Slight, earthy.	1.00	7.15	2.60	.0000	.0244	.0186	.0058	.48	.0400	.0000	2.5
Av.	....	....	....	....	0.63	5.56	1.72	.0011	.0190	.0168	.0022	.38	.0232	.0001	2.1

Odor, vegetable. —— The samples were collected from the brook, where it is crossed by the Fitchburg Railroad, just above the reservoir.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	6	10	12	3	7	11	3	7	4	4
Number of sample,	6978	7086	7189	7285	7384	7533	7760	7890	8020	8197	8298
PLANTS.											
Diatomaceæ,	**5**	**45**	**75**	**76**	**21**	**14**	**15**	**17**	**39**	**10**	**2**
Asterionella,	2	0	17	0	0	0	0	0	0	0	0
Cocconeis,	0	0	0	0	0	4	2	0	0	0	1
Diatoma,	1	0	18	0	1	0	0	3	0	2	0
Fragilaria,	0	0	0	4	0	0	3	4	0	1	0
Melosira,	0	0	11	0	0	3	0	4	0	0	0
Meridion,	1	30	4	0	pr.	0	0	1	1	0	0
Navicula,	0	3	1	3	4	4	3	3	34	2	pr.
Nitzschia,	0	9	0	15	18	1	0	0	0	0	0
Synedra,	1	3	24	54	1	0	7	2	8	1	1
Tabellaria,	0	pr.	pr.	pr.	2	2	pr.	0	1	4	pr.

CAMBRIDGE.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.										
	Feb.	Mar.	April.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.											
Cyanophyceæ. Oscillaria, .	0	0	0	pr.	5	0	0	1	0	0	0
Algæ, ...	0	pr.	pr.	0	2	2	13	0	6	7	0
Chlorococcus, ...	0	0	0	0	2	2	13	0	0	1	0
Hyalotheca, ...	0	0	pr.	0	0	0	0	0	6	0	0
Protococcus, ...	0	pr.	0	0	0	0	0	0	0	6	0
Fungi. Crenothrix, ...	pr.	3	0	108	0	27	79	73	17	26	1
ANIMALS.											
Rhizopoda. Actinophrys, . .	0	0	0	0	0	0	0	3	0	0	0
Infusoria. Trachelomonas, . .	1	pr.	0	0	1	0	0	1	0	0	pr.
Miscellaneous. Zoöglœa, ...	54	10	40	546	8	11	3	80	202	67	8
TOTAL, ...	60	58	115	730	37	54	110	155	204	110	11

Chemical Examination of Water from Stony Brook Storage Reservoir, Cambridge Water Works, in Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6872	Jan. 5	Jan. 6	V. slight.	V. slight.	0.60	4.70	1.45	.0038	.0194	.0186	.0008	.35	.0420	.0000	2.1
6979	Feb. 3	Feb. 4	None.	V. slight	0.60	4.05	1.65	.0042	.0170	.0158	.0012	.22	.0350	.0001	1.7
7067	Mar. 3	Mar. 4	V. slight	None.	0.25	4.35	1.75	.0002	.0102	.0092	.0010	.22	.0050	.0000	1.4
7188	Apr. 6	Apr. 8	Slight.	Slight.	0.60	3.80	1.20	.0006	.0178	.0158	.0020	.33	.0200	.0001	1.4
7286	May 5	May 6	V. slight.	Slight.	0 60	4.40	1.65	.0000	.0200	.0192	.0008	.32	.0100	.0000	1.9
7385	June 2	June 4	V. slight.	Slight.	0.60	5.05	2.45	.0008	.0208	.0186	.0022	.33	.0180	.0005	1.7
7534	July 6	July 7	Distinct.	Cons.	0.65	5.75	2.05	.0018	.0260	.0198	.0062	.32	.0050	.0002	1.8
7761	Aug. 10	Aug. 11	Slight.	Slight.	0.50	5.40	1.70	.0020	.0276	.0216	.0060	.41	.0070	.0001	1.9
7889	Sept. 2	Sept. 3	Distinct.	Slight.	0.40	5.00	2.10	.0020	.0234	.0208	.0026	.35	.0090	.0001	1.9
8021	Oct. 6	Oct. 7	Distinct.	Cons.	0.50	5.85	2.30	.0000	.0274	.0220	.0054	.34	.0070	.0000	2.1
8198	Nov. 3	Nov. 4	Slight.	Cons., green.	0.75	5.35	1.85	.0010	.0256	.0222	.0034	.42	.0100	.0002	2.2
8299	Dec. 3	Dec. 4	Slight.	Cons.	0.70	6.15	2.15	.0024	.0206	.0166	.0040	.45	.0280	.0000	2.3
Av.	....	....	....	....	0.56	4.99	1.86	.0016	.0213	.0183	.0030	.34	.0163	.0001	1.9

Odor, vegetable; rarely none. — The samples were collected from the reservoir, near the surface, at the dam.

CAMBRIDGE.

Microscopical Examination of Water from Stony Brook Storage Reservoir, Cambridge Water Works, in Waltham.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
Day of examination,	7	5	6	10	12	4	7	11	3	7	4	4
Number of sample,	6872	6979	7087	7188	7286	7385	7534	7761	7889	8021	8198	8299
PLANTS.												
Diatomaceæ,	**4**	pr.	pr.	**85**	**84**	**21**	**727**	**174**	**641**	**695**	**763**	**598**
Asterionella,	3	0	0	0	0	0	402	32	39	140	14	9
Cyclotella,	0	0	0	0	0	pr.	0	1	8	2	67	3
Cymbella,	0	0	0	0	0	1	1	1	1	pr.	0	2
Diatoma,	0	0	0	5	8	7	16	0	0	1	0	pr.
Fragilaria,	0	0	0	0	0	0	0	14	34	140	19	0
Meridion,	0	0	pr.	26	0	1	5	0	0	20	1	0
Navicula,	0	0	0	1	1	pr.	pr.	1	1	38	32	2
Nitzschia,	0	0	0	0	0	0	18	0	0	0	0	0
Synedra,	0	pr.	0	52	68	8	19	17	302	152	18	2
Tabellaria,	1	0	0	1	7	9	266	108	256	202	612	580
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**166**	**58**	**37**	**13**	**10**	**0**
Clathrocystis,	0	0	0	0	0	0	0	15	1	4	7	0
Cœlosphærium,	0	0	0	0	0	0	166	1	pr.	pr.	0	0
Microcystis,	0	0	0	0	0	0	0	42	36	2	3	0
Nostoc,	0	0	0	0	0	0	0	0	0	7	0	0
Algæ,	**0**	**0**	**0**	**4**	pr.	**16**	**583**	**736**	**34**	**706**	**814**	**3**
Botryococcus,	0	0	0	0	0	0	36	0	pr.	0	0	0
Chlorococcus,	0	0	0	0	0	14	166	700	16	0	12	0
Closterium,	0	0	0	0	0	0	24	29	pr.	702	796	3
Protococcus,	0	0	0	4	0	0	0	0	0	0	1	0
Raphidium,	0	0	0	0	0	0	107	1	0	1	2	0
Staurastrum,	0	0	0	0	pr.	2	250	6	11	1	0	pr.
Staurogenia,	0	0	0	0	0	0	0	0	7	2	3	pr.
Fungi. Crenothrix,	**0**	pr.	pr.	**2**	pr.	pr.	**0**	pr.	pr.	**2**	**0**	**3**
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	pr.	**4**	pr.
Infusoria,	**0**	**0**	**0**	pr.	pr.	**3**	**8**	**5**	**12**	**29**	**2**	**4**
Dinobryon,	0	0	0	0	0	0	7	0	0	22	0	0
Peridinium,	0	0	0	0	0	0	pr.	2	6	0	pr.	0
Trachelomonas,	0	0	0	pr.	pr.	3	1	pr.	6	7	2	4
Vorticella,	0	0	0	0	0	0	0	3	0	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	**0**	**2**	pr.	pr.	**0**	pr.	**0**	**0**
Cyclops,	0	0	0	0	0	0	pr.	pr.	0	pr.	0	0
Daphnia,	0	0	0	0	0	0	pr.	0	0	0	0	0
Ova,	0	0	0	0	0	2	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**25**	**6**	**170**	**240**	**528**	**5**	**5**	**1**	**182**	**248**	**180**	**4**
TOTAL,	29	6	170	331	612	48	1,489	974	916	1,693	1,783	612

CAMBRIDGE.

Table showing Heights of Water in Fresh Pond and Stony Brook Reservoir at the times when Samples of Water were collected for Analysis.

[Heights are in feet above Cambridge city base.]

Fresh Pond. High Water, 16.85.		Stony Brook. Rollway, 81.00.	
Date.	Height of Water.	Date.	Height of Water.
January 5,	16.22	January 5,	81.54
February 3,	16.26	February 3,	81.87
March 3,	16.33	March 3,	81.58
April 6,	16.68	April 6,	81.98
May 5,	16.40	May 5,	81.21
June 2,	16.25	June 12,	80.83
July 7,	15.31	July 6,	80.87
August 10,	13.25	August 10,	80.89
September 2,	12.76	September 2,	80.45
October 6,	14.07	October 6,	74.00
November 3,	14.68	November 3,	73.37
December 3,	14.78	December 3,	75.86

Water Supply of Chelsea.

(See *Boston, Mystic Works.*)

Water Supply of Chicopee.

The town of Chicopee became a city in 1891, and by the provisions of the charter the Chicopee Falls and Chicopee Central Fire Districts were abolished, the portions of the water works owned by these districts becoming the property of the city. The different portions of the city are still supplied with water by private companies, as heretofore.

Proposed Water Supply of the Village of Willimansett in Chicopee.

Chemical Examination of Water from Powderhorn Brook in Chicopee, the Proposed Source of Supply for the Village of Willimansett.

[Parts per 100,000.]

Number.	Date of: Collection.	Date of: Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8378	Dec. 29	Dec. 31	None.	Slight.	0.03	2.95	0.40	.0000	.0014	.0010	.0004	.10	.0020	.0000	0.5

Odor, none; on heating, very faintly vegetable. —— The sample was collected from the brook.

Microscopical Examination.

No organisms.

CLINTON.

WATER SUPPLY OF CLINTON AND LANCASTER.

Chemical Examination of Water from Wekepeke Brook in Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8367	Dec. 22	Dec. 23	V. slight.	Slight.	0.03	3.85	0.80	.0006	.0028	.0018	.0010	.17	.0030	.0000	1.1

Odor, faintly vegetable.——The sample was collected from the brook below Lynde's Pond and just above the point of diversion into the "Basin" of the Clinton Water Works.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 1; *Synedra*, 2. Fungi, *Crenothrix*, 5. Vermes, *Anurea*, pr. Miscellaneous, *Zoöglœa*, 23. Total, 31.

Chemical Examination of Water from Heywood's Pond, Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8366	Dec. 22	Dec. 23	Slight.	Slight.	0.60	4.60	2.20	.0000	.0152	.0116	.0036	.19	.0020	.0000	0.6

Odor, very faintly vegetable, becoming decidedly vegetable and disagreeable on heating.——The sample was collected from the pond at the dam. The town of Clinton can take water from the brook which flows from this pond, but exercises this right only when the other sources of supply are low.

Microscopical Examination.

Diatomaceæ, *Synedra*, 23. Algæ, *Chlorococcus*, 1; *Raphidium*, 3. Fungi, *Crenothrix*, 4. Infusoria, *Dinobryon*, 5. Miscellaneous, *Zoöglœa*, 14. Total, 50.

CLINTON.

Chemical Examination of Water from East Waushacum Pond, Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8365	Dec. 22	Dec. 23	None.	V. slight.	0.0	2.35	0.70	.0000	.0090	.0084	.0006	.16	.0030	.0000	0.5

Odor, none, becoming faintly vegetable on heating. —— The sample was collected from the pond at its outlet, with reference to its use as an additional source of water supply for Clinton.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 22. Cyanophyceæ, *Microcystis*, 1. Fungi, *Crenothrix*, 2. Miscellaneous, *Zoöglœa*, 8. Total, 33.

Water Supply of Cottage City. — Cottage City Water Company.

Chemical Examination of Water from the Springs of the Cottage City Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8300	Dec. 2	Dec. 4	None.	Slight.	0.00	4.10	.0000	.0000	.87	.0200	.0000	0.3

Odor, none. —— The sample was collected from the pump-well, at the pumping station.

Microscopical Examination.

Diatomaceæ, *Tabellaria*, 3. Fungi, *Molds*, pr. Miscellaneous, *Zoöglœa*, pr. Total, 3.

DALTON.

Water Supply of Dalton Fire District, Dalton.

Chemical Examination of Water from Egypt and Burr Brooks, Dalton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8140	Oct. 19	Oct. 20	None.	V. slight.	0.10	2.45	0.75	.0000	.0028	.0026	.0002	.05	.0350	.0001	0.48
8141	Oct. 19	Oct. 20	V. slight.	Cons.	0.10	3.70	0.90	.0000	.0048	.0014	.0034	.05	.0120	.0000	1.69

Odor, none. —— No. 8140 was collected from Egypt Brook, about 250 feet above the reservoir. No. 8141 was collected from a four-inch pipe which conveys water from Burr Brook into Egypt Brook.

Microscopical Examination.

8140. Cyanophyceæ, *Clathrocystis*, pr. Fungi, *Beggiatoa*, 1; *Crenothrix*, 2. Miscellaneous, *Zoöglœa*, 6. Total, 9.

8141. Diatomaceæ, *Cyclotella*, pr.; *Meridion*, pr.; *Navicula*, 7; *Synedra*, pr.; *Tabellaria*, 1, Cyanophyceæ, *Oscillaria*, pr. Algæ, *Chlorococcus*, pr. Fungi, *Crenothrix*, 27. Miscellaneous, *Zoöglœa*, 122. Total, 157.

Water Supply of Danvers.

Chemical Examination of Water from Middleton Pond, Middleton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6933	Jan. 30	Jan. 30	V. slight.	V. slight.	0.90	4.00	1.45	.0004	.0204	.0204	.0000	.32	.0090	.0000	1.7
6996	Feb. 10	Feb. 10	Slight	Slight.	0.80	3.65	1.60	.0034	.0254	.0212	.0042	.23	.0040	.0001	1.3
7102	Mar. 10	Mar. 11	V. slight.	V. slight.	0.75	3.85	1.55	.0004	.0176	.0156	.0020	.29	.0200	.0001	1.1
7214	Apr. 14	Apr. 15	V. slight.	V. slight.	0.65	3.75	1.45	.0006	.0196	.0164	.0032	.32	.0050	.0000	0.9
7306	May 12	May 13	V. slight	Slight	0.70	3.80	1.25	.0000	.0152	.0138	.0014	.31	.0020	.0000	1.3
7414	June 9	June 10	Slight.	V. slight.	0.55	3.65	1.40	.0000	.0210	.0174	.0036	.29	.0020	.0001	0.9
7562	July 14	July 15	Slight.	Slight.	0.50	3.45	1.45	.0040	.0234	.0184	.0050	.32	.0030	.0001	0.8
7780	Aug. 11	Aug. 11	V. slight.	V. slight.	0.50	3.70	1.85	.0000	.0180	.0142	.0038	.32	.0090	.0000	1.1
7906	Sept. 8	Sept. 9	Slight.	Slight.	0.45	3.20	1.20	.0000	.0194	.0172	.0022	.33	.0000	.0000	1.1
8015	Oct. 6	Oct. 7	Slight.	Slight.	0.55	3.50	1.85	.0004	.0188	.0166	.0022	.33	.0000	.0000	0.8
8209	Nov. 4	Nov. 4	Slight.	V. slight.	0.45	3.55	1.65	.0000	.0182	.0164	.0018	.34	.0030	.0002	0.9
8311	Dec. 8	Dec. 9	Slight.	V. slight.	0.35	3.60	1.75	.0000	.0160	.0138	.0022	.35	.0070	.0000	0.5
Av.	....	....	....	....	0.60	3.64	1.54	.0008	.0195	.0168	.0027	.36	.0053	.0001	1.0

Odor, vegetable. —— The samples were collected from a faucet at the pumping station of the Danvers Water Works, while pumping.

Middleton Pond remained full from the 1st of January until about the middle of May. From that time the pond went steadily down until it was 38 inches below high water on October 1, and remained practically at that point until December 1. It was about 32 inches below high water on Jan. 1, 1892.

DANVERS.

Microscopical Examination of Water from Middleton Pond, Middleton.

[Number of organisms per cubic centimeter.]

	1891.											
	Feb.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	12	11	16	13	9	15	12	10	7	5	9
Number of sample,	6953	6996	7102	7214	7306	7414	7562	7780	7906	8015	8209	8311
PLANTS.												
Diatomaceæ,	57	1	2	57	341	422	143	104	172	156	564	290
Asterionella,	1	1	2	12	184	0	0	60	10	2	86	248
Cyclotella,	0	0	0	0	0	0	104	19	32	1	4	4
Diatoma,	0	0	0	8	0	0	0	0	6	2	0	0
Melosira,	0	0	0	11	18	4	0	0	0	0	20	21
Navicula,	0	0	0	1	0	pr.	0	1	0	3	pr.	0
Stephanodiscus,	56	0	0	3	13	218	0	0	0	0	pr.	0
Synedra,	pr.	0	pr.	5	0	0	0	0	pr	0	2	1
Tabellaria,	pr.	0	pr.	17	126	200	39	24	124	148	452	16
Cyanophyceæ,	0	0	0	0	0	34	37	24	79	90	77	25
Anabæna,	0	0	0	0	0	0	0	0	0	11	3	0
Chroöcoccus,	0	0	0	0	0	0	29	0	15	10	2	0
Cœlosphærium,	0	0	0	0	0	0	0	0	0	68	0	25
Microcystis,	0	0	0	0	0	0	0	16	64	1	72	0
Nostoc,	0	0	0	0	0	34	8	8	0	0	0	0
Algæ,	0	0	0	0	0	4	30	38	265	6	0	0
Botryococcus,	0	0	0	0	0	0	0	34	0	0	0	0
Chlorococcus,	0	0	0	0	0	4	28	4	256	6	0	0
Raphidium,	0	0	0	0	0	0	2	0	9	0	0	0
Fungi. Crenothrix,	7	0	1	7	1	0	0	0	0	0	0	0
ANIMALS.												
Rhizopoda,	1	0	0	1	0	0	0	0	1	pr.	2	pr.
Actinophrys,	0	0	0	1	0	0	0	0	1	pr.	1	pr.
Difflugia,	1	0	0	pr.	pr.	0	0	0	0	0	1	0
Infusoria,	104	0	159	6	1	0	0	2	5	0	11	10
Dinobryon,	104	0	130	5	pr.	0	0	0	5	0	6	4
Dinobryon cases,	0	0	0	0	0	0	0	0	0	0	0	4
Peridinium,	0	0	28	1	1	0	0	2	pr.	0	pr.	1
Trachelomonas,	0	0	1	0	0	0	0	0	0	0	5	1
Crustacea. Cyclops,	0	0	0	0	pr.	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	1	390	0	254	56	0	4	0	82	113	36	1
TOTAL,	170	391	162	325	399	460	214	168	604	365	690	326

WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

A second iron tank was built in 1890. It is 42 feet in diameter and 51 feet high, and open at the top.

EAST BRIDGEWATER.

WATER SUPPLY OF EAST BRIDGEWATER.

(See *Bridgewater.*)

WATER SUPPLY OF EASTHAMPTON.

In 1891, during investigations made for the purpose of obtaining a new supply of water for the town, samples of water were collected from several brooks and streams in the vicinity of the town, the analyses of which are given in the following table.

Chemical Examination of Water from various sources in Easthampton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
7041	Feb. 19	Feb. 21	Distinct.	Slight.	0.10	1.85	0.50	.0000	.0054	.0030	.0024	.08	.0200	.0000	0.6
7337	May 19	May 21	V. slight.	Cons.	0.25	3.80	1.25	.0000	.0076	.0070	.0006	.07	.0060	.0000	1.1
7927	Sept. 14	Sept. 15	Slight.	Slight.	0.25	4.45	1.35	.0000	.0066	.0060	.0006	.09	.0070	.0000	1.8
7662	July 24	July 27	None.	Slight.	0.00	6.90	2.20	.0028	.0052	.0016	.0036	.16	.0150	.0000	3.5
7926	Sept. 14	Sept. 15	V. slight.	Cons.	0.02	6.05	1.40	.0000	.0028	.0014	.0014	.10	.0200	.0000	3.5
7040	Feb. 19	Feb. 21	-	-	0.10	-	-	.0000	-	-	-	.10	-	-	1.3
7338	May 19	May 21	V. slight.	Slight.	0.15	6.95	1.60	.0000	.0050	.0034	.0016	.08	.0090	.0000	1.6
7037	Feb. 19	Feb. 21	-	-	0.00	-	-	.0000	-	-	-	.12	-	-	2.5
7038	Feb. 19	Feb. 21	-	-	0.03	-	-	.0000	-	-	-	.11	-	-	2.7
7039	Feb. 19	Feb. 21	-	-	0.02	-	-	.0000	-	-	-	.10	-	-	2.6
7042	Feb. 19	Feb. 21	Slight.	Heavy, earthy.	0.20	2.60	0.60	.0000	.0054	.0020	.0034	.09	.0200	.0000	1.4
8157	Oct. 21	Oct. 22	Slight.	Cons., earthy.	0.75	4.80	1.75	.0000	.0126	.0108	.0018	.12	.0090	.0001	1.3

Odor of the first three samples, faintly vegetable; of all others none, excepting the last, which was distinctly vegetable and mouldy.

The first three samples were collected from Bassett Brook, Nos. 7041 and 7927 being collected at West Street just above the mouth of the stream, and No. 7337 at Park Hill road, about 1¼ miles farther up stream.

Nos. 7662 and 7926 were collected from Broad Brook just above its confluence with Rum Brook. Nos. 7040 and 7338 were from the north branch of the Manhan River, No. 7040 being collected just above its confluence with the south branch, and No. 7338 at Kingsley Bridge, Loudville. No. 7037 was collected from the brook at the entrance to the Mt. Tom reservoir. No. 7038 was collected from Brandy Brook; No. 7039 from Rum Brook; No. 7042 from the brook which flows northeasterly from the vicinity of Pomeroy Mountain into the north branch of the Manhan River, near its mouth; No. 8157 from Pomeroy Brook at West Street.

EASTHAMPTON.

Microscopical Examination of Water from various sources in Easthampton.

[Number of organisms per cubic centimeter.]

	1891.											
	Feb.	May.	Sept.	July.	Sept.	-	May.	-	-	-	May.	Oct.
Day of examination,	26	22	15	27	15	-	22	-	-	-	23	22
Number of sample,	7041	7337	7927	7662	7926	7040	7338	7037	7038	7039	7042	8157
PLANTS.												
Diatomaceæ,	1	78	2	8	16	-	24	-	-	-	2	5
Asterionella,	0	0	2	0	1	-	0	-	-	-	0	0
Cocconeis,	0	0	0	pr.	0	-	0	-	-	-	0	0
Cyclotella,	0	0	0	0	pr.	-	0	-	-	-	0	0
Cymbella,	0	0	0	0	pr.	-	pr.	-	-	-	0	pr.
Diatoma,	0	0	0	pr.	0	-	4	-	-	-	pr.	0
Fragilaria,	0	0	0	0	0	-	0	-	-	-	0	3
Gomphonema,	0	0	0	0	0	-	pr.	-	-	-	0	0
Melosira,	0	0	0	2	0	-	0	-	-	-	0	0
Meridion,	1	1	0	0	0	-	0	-	-	-	1	pr.
Navicula,	0	2	0	2	1	-	2	-	-	-	pr.	1
Nitzschia,	0	21	0	0	0	-	0	-	-	-	1	0
Synedra,	0	54	0	1	14	-	18	-	-	-	0	0
Tabellaria,	0	0	0	3	0	-	0	-	-	-	pr.	1
Cyanophyceæ,	0	0	0	0	0	-	1	-	-	-	0	pr.
Clathrocystis,	0	0	0	0	0	-	0	-	-	-	0	pr.
Oscillaria,	0	0	0	0	0	-	1	-	-	-	0	0
Algæ,	0	0	0	0	pr.	-	pr.	-	-	-	0	pr.
Closterium,	0	0	0	0	0	-	pr.	-	-	-	0	pr.
Cosmarium,	0	0	0	0	pr.	-	0	-	-	-	0	0
Spirogyra,	0	0	0	0	0	-	0	-	-	-	0	pr.
Ulothrix,	0	0	0	0	0	-	pr.	-	-	-	0	0
Zoöspores,	0	0	0	0	0	-	0	-	-	-	0	pr.
Fungi,	2	10	44	2	4	-	2	-	-	-	0	4
Beggiatoa,	0	0	0	2	0	-	0	-	-	-	0	0
Crenothrix,	2	10	44	0	4	-	2	-	-	-	0	1
Molds,	0	0	0	0	0	-	0	-	-	-	0	2
Saccharomyces,	0	0	0	0	0	-	0	-	-	-	0	1
ANIMALS.												
Infusoria,	0	pr.	2	1	1	-	0	-	-	-	0	1
Monas,	0	0	1	0	0	-	0	-	-	-	0	0
Trachelomonas,	0	pr.	1	1	1	-	0	-	-	-	0	
Miscellaneous. Zoöglœa,	1,146	102	452	33	17	-	96	-	-	-	1,164	67
TOTAL,	1,149	190	500	44	38	-	123	-	-	-	1,166	77

EASTON.

Water Supply of North Easton Village District, Easton.

The water for supplying this village is pumped from a well as heretofore, but with a view to increasing the capacity of the works a small storage reservoir has been constructed in the valley about 100 feet above the well. This reservoir is 6 feet deep and was carefully prepared for the reception of water by the removal of all vegetable matter and by excavating to the depth above mentioned. The capacity of the reservoir is 5,000,000 gallons. At a depth of 5 feet beneath the bottom of the reservoir is a system of pipes, laid with open joints, with a view to obtaining filtered water. A pipe with tight joints has also been laid from the Lincoln spring, above the reservoir, to the well. The original well has furnished a sufficient supply of water up to the present time, so that there has been no occasion to take water from the pipes beneath the reservoir. A second small storage reservoir has been built above the first one and was filled in December, 1891.

Water Supply of Everett.

(See *Boston, Mystic Works.*)

Falmouth.

Chemical Examination of Water from Long Pond, Falmouth.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1891.														
7116	Mar. 12	Mar. 13	None.	V. slight.	0.0	3.35	1.40	.0000	.0088	.0066	.0022	.87	.0150	.0000	0.5

Odor, none. —— The sample was collected from the pond at its northerly end.

Microscopical Examination.

Diatomaceæ, *Asterionella*, pr.; *Navicula*, pr.; *Stephanodiscus*, 1; *Synedra*, 18; *Tabellaria*, 112. Algæ, *Raphidium*, 1. Infusoria, *Dinobryon*, 197. Miscellaneous, *Zoöglæa*, 38. Total, 367.

Water Supply of Fitchburg.

Chemical Examination of Water from Scott Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1891.														
6938	Jan. 21	Jan. 22	V. slight.	V. slight.	0.20	2.50	0.95	.0000	.0140	.0108	.0032	.14	.0100	.0000	0.9
7065	Feb. 27	Mar. 2	None.	None.	0.20	1.85	0.55	.0004	.0066	.0054	.0012	.08	.0180	.0000	0.8
7143	Mar. 24	Mar. 26	V. slight.	V. slight.	0.15	2.35	0.95	.0000	.0116	.0092	.0024	.20	.0200	.0000	0.6
7240	Apr. 21	Apr. 23	V. slight.	V. slight.	0.10	2.75	1.00	.0026	.0114	.0102	.0012	.12	.0100	.0000	0.5
7339	May 20	May 21	None.	V. slight.	0.03	2.20	1.00	.0000	.0056	.0030	.0026	.09	.0120	.0001	0.5
7490	June 24	June 25	Distinct.	Consid.	0.10	2.25	1.05	.0040	.0268	.0210	.0058	.14	.0020	.0001	0.3
7726	July 28	July 30	Distinct.	Slight.	0.20	2.85	1.35	.0010	.0232	.0212	.0020	.14	.0050	.0000	0.3
7865	Aug. 27	Aug. 28	V. slight.	Slight.	0.15	2.10	0.85	.0000	.0050	.0040	.0010	.15	.0050	.0000	0.8
7961	Sept. 21	Sept 22	V. slight.	V. slight.	0.08	2.85	1.00	.0000	.0060	.0046	.0014	.15	.0030	.0000	0.8
8146	Oct. 20	Oct. 21	Distinct, milky.	Slight, green.	0.10	2.95	1.35	.0000	.0310	.0206	.0104	.14	.0050	.0001	0.3
8260	Nov. 16	Nov. 17	Distinct.	Consid., green.	0.09	2.75	1.15	.0000	.0256	.0164	.0092	.19	.0020	.0000	0.3
8363	Dec. 22	Dec. 23	V. slight.	V. slight.	0.15	3.25	1.35	.0000	.0086	.0062	.0024	.16	.0070	.0000	0.9
Av.	....	....	....	....	0.13	2.55	1.05	.0007	.0146	.0110	.0036	.14	.0082	.0000	0.6

Odor, generally vegetable, frequently none.——The samples were collected from the reservoir at the gate-house, one foot beneath the surface. No water was used from this reservoir during the first six months of 1891. For record of height of water in this reservoir see page 122.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	23	5	26	23	22	26	30	29	22	21	18	23
Number of sample,	6938	7065	7143	7240	7339	7490	7726	7865	7961	8146	8260	8363
PLANTS.												
Diatomaceæ,	**1**	**4**	**5**	**100**	**29**	**77**	**256**	**251**	**68**	**536**	**3,075**	**5**
Asterionella,	0	3	0	26	0	24	77	18	0	176	440	3
Diatoma,	0	0	0	7	0	0	1	14	0	0	0	0
Fragilaria,	0	0	0	0	0	0	0	0	19	0	0	0
Melosira,	0	1	0	4	0	0	4	1	47	16	31	2
Meridion,	0	pr.	4	0	10	0	0	0	0	0	0	0
Navicula,	0	0	0	2	3	0	pr.	pr.	2	4	0	0
Nitzschia,	0	0	0	0	0	10	0	pr.	0	0	0	0
Synedra,	1	pr.	1	54	14	3	87	184	0	88	348	0
Tabellaria,	0	0	0	7	2	40	87	34	0	252	2,256	0
Cyanophyceæ. Chroöcoccus,	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Algæ,	**4**	**0**	**1**	**14**	**0**	**47**	**9**	**40**	**0**	**420**	**203**	**0**
Arthrodesmus,	0	0	0	0	0	5	0	0	0	0	1	0
Chlorococcus,	0	0	1	0	0	9	1	0	0	264	115	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	52	38	0
Pediastrum,	0	0	0	0	0	pr.	1	1	0	7	2	0
Raphidium,	0	0	0	14	0	0	3	3	0	30	4	0
Scenedesmus,	0	0	0	0	0	0	1	0	0	5	11	0
Staurastrum,	pr.	0	0	pr.	0	33	3	36	0	62	20	0
Zoöspores,	4	0	0	0	0	0	0	0	0	0	12	0
Fungi. Crenothrix,	**0**	**1**	**1**	**1**	**2**	**0**	**0**	**2**	**0**	**0**	**0**	**2**

FITCHBURG.

Microscopical Examination of Water from Scott Reservoir, Fitchburg — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda. Difflugia,	0	0	0	0	0	pr.	0	4	0	0	3	0
Infusoria,	72	pr.	pr.	4	0	828	517	219	0	33	94	4
Dinobryon,	0	0	0	pr.	0	392	261	4	0	3	84	4
Dinobryon cases,	13	0	0	0	0	436	75	0	0	0	0	0
Monas,	0	0	0	2	0	0	0	0	0	0	3	0
Peridinium,	59	pr.	pr.	2	0	pr.	36	76	0	29	2	pr.
Peridinium cases,	0	0	0	0	0	0	145	138	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	1	0	1	5	0
Vermes. Anurea,	0	0	0	0	0	pr.	3	pr.	0	0	1	0
Crustacea,	0	0	0	0	0	pr.	0	pr.	0	0	1	0
Bosmina,	0	0	0	0	0	0	0	pr.	0	0	pr.	0
Entomostracan ova,	0	0	0	0	0	pr.	0	0	0	0	1	0
Miscellaneous. Zoöglœa,	14	50	4	208	34	37	110	228	55	59	224	24
TOTAL,	91	55	11	332	65	989	895	744	123	1,048	3,601	35

Chemical Examination of Water from Falulah Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1891.														
6937	Jan. 21	Jan. 22	V. slight.	Slight.	0.20	2.35	0.75	.0008	.0200	.0176	.0024	.14	.0150	.0000	0.8
7064	Feb. 27	Mar. 2	V. slight.	V. slight.	0.20	2.15	0.85	.0012	.0052	.0044	.0008	.10	.0180	.0000	0.8
7142	Mar. 24	Mar. 26	Slight.	V. slight.	0.15	2.15	0.55	.0010	.0090	.0056	.0034	.19	.0200	.0000	0.8
7241	Apr. 21	Apr. 23	Slight.	Slight.	0.15	3.10	1.60	.0060	.0124	.0108	.0016	.13	.0070	.0000	0.5
7340	May 20	May 21	Slight.	Slight.	0.15	2.60	1.40	.0008	.0222	.0190	.0032	.10	.0020	.0000	0.5
7489	June 24	June 25	Slight.	Slight.	0.65	2.95	0.95	.0090	.0246	.0216	.0030	.07	.0080	.0002	0.5
7725	July 28	July 30	None.	V. slight.	0.05	2.80	0.50	.0000	.0056	.0050	.0006	.13	.0070	.0000	0.7
7866	Aug. 27	Aug. 28	Distinct.	Slight.	0.10	3.00	1.00	.0014	.0262	.0176	.0086	.14	.0060	.0000	0.2
7962	Sept. 21	Sept. 22	Distinct.	Slight, green.	0.10	2.05	1.15	.0000	.0298	.0210	.0088	.17	.0050	.0000	0.5
8147	Oct 20	Oct. 21	V. slight	V. slight.	0.20	3.45	1.25	.0008	.0232	.0196	.0036	.26	.0090	.0000	0.8
8261	Nov. 16	Nov. 17	None.	V. slight	0.07	3.40	1.25	.0000	.0034	.0020	.0014	.18	.0020	.0000	0.6
8362	Dec. 22	Dec. 23	V. slight.	None.	0.03	3.30	1.30	.0040	.0046	.0042	.0004	.17	.0100	.0000	0.8
Av.	....	....	....	....	0.17	2.77	1.05	.0021	.0155	.0124	.0031	.15	.0090	.0000	0.6

Odor, generally very faintly vegetable, frequently none. —— The samples were collected from the reservoir at the gate-house, at a depth of one foot beneath the surface, except in July, August and September, when the reservoir was empty, and they were consequently taken from the brook. The water acquired a disagreeable taste in June and the reservoir was drawn off June 15, but was allowed to fill again after a few days. Owing to the prevailing drought this source furnished only a very small part of the water used in the city during a portion of the summer and autumn.

FITCHBURG,

Microscopical Examination of Water from Falulah Reservoir, Fitchburg.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	23	5	26	23	22	26	30	29	22	21	18	23
Number of sample,	6937	7064	7142	7241	7340	7489	7725	7866	7962	8147	8261	8362
PLANTS.												
Diatomaceæ,	**2**	**6**	**14**	**22**	**92**	**2**	**1**	**626**	**3,533**	**26**	**3**	**1**
Asterionella,	0	3	4	6	10	0	0	0	22	19	0	0
Diatoma,	0	0	1	3	0	0	0	0	11	0	0	0
Melosira,	0	2	0	0	0	0	0	624	2	6	0	0
Meridion,	0	pr.	4	1	0	0	0	0	0	0	pr.	0
Stephanodiscus,	1	0	5	pr.	0	0	0	0	0	1	0	0
Synedra,	1	1	pr.	7	80	pr.	0	0	3,402	0	3	0
Tabellaria,	0	0	0	5	2	2	1	2	96	pr.	0	1
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**724**	**0**	**72**	**0**	**0**
Aphanocapsa,	0	0	0	0	0	0	0	232	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	0	44	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	0	184	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	160	0	0	0	0
Microcystis,	0	0	0	0	0	0	0	104	0	72	0	0
Algæ,	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**48**	**86**	**34**	**0**	**0**
Botryococcus,	0	0	0	0	0	0	0	0	0	16	0	0
Chlorococcus,	0	0	0	0	0	3	0	0	0	18	0	0
Scenedesmus,	0	0	0	0	0	0	0	32	pr.	0	0	0
Sorastrum,	0	0	0	0	0	0	0	6	0	0	0	0
Staurastrum,	0	0	0	0	0	0	0	10	86	0	0	0
Fungi,	**1**	**2**	**1**	**64**	**68**	**35**	**1**	**pr.**	**0**	**0**	**3**	**0**
Crenothrix,	1	2	1	48	68	35	1	pr.	0	0	3	0
Molds,	0	0	0	16	0	0	0	0	0	0	0	0
ANIMALS.												
Infusoria,	**16**	**0**	**10**	**0**	**5**	**1**	**0**	**30**	**170**	**pr.**	**0**	**0**
Dinobryon,	0	0	6	0	5	0	0	0	2	0	0	0
Euglena,	0	0	0	0	0	0	0	0	2	0	0	0
Monas,	0	0	0	0	0	0	0	0	5	pr.	0	0
Peridinium,	15	0	4	0	0	pr.	0	0	158	0	0	0
Trachelomonas,	1	0	0	0	0	1	0	30	3	0	0	0
Vermes,	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**2**	**0**	**0**	**0**	**0**
Anurea,	0	0	0	0	1	0	0	0	0	0	0	0
Rotatorian ova,	0	0	0	0	0	1	0	2	0	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**pr.**	**0**	**0**	**0**	**0**
Cyclops,	0	0	0	0	0	0	0	pr.	0	0	0	0
Entomostracan ova,	0	0	0	0	0	pr.	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**102**	**246**	**21**	**172**	**324**	**26**	**2**	**328**	**218**	**68**	**0**	**18**
TOTAL,	121	254	46	258	490	70	4	1,758	4,007	220	6	19

FITCHBURG.

Chemical Examination of Water from Overlook Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1891.														
6936	Jan. 21	Jan. 22	V. slight.	V. slight.	0.20	2.65	0.85	.0024	.0108	.0072	.0036	.14	.0100	.0000	0.8

Odor, none.——The sample was collected from the reservoir near the inlet where water enters from the conduit.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 9; *Melosira*, 17; *Meridion*, 1; *Navicula*, pr.; *Nitzschia*, pr.; *Stephanodiscus*, 2; *Synedra*, 3; *Tabellaria*, pr.; Algæ, *Raphidium*, 1. Infusoria, *Dinobryon cases*, 1; *Peridinium*, pr. Miscellaneous, *Zoöglœa*, 40. Total, 74.

Table showing the Average Monthly Height of Water in Falulah, Overlook and Scott Reservoirs, Fitchburg.

[The height of water in Falulah Reservoir when full is 20 feet; in Overlook and Scott Reservoirs, 40 feet.]

Months.	Height of Water in Reservoirs. Falulah.	Overlook.	Scott.
1891.			
January,	20.1	33.1	40.0
February,	20.0	39.2	40.0
March,	20.1	39.8	40.0
April,	20.1	39.3	40.0
May,	19.7	39.9	39.9
June,	10.7	38.5	39.9
July,	0.0	33.1	38.8
August,	0.0	29.1	35.3
September,	0.0	27.4	28.9
October,	7.0	26.2	19.9
November,	7.3	25.5	14.7
December,	19.0	30.6	14.3

FITCHBURG.

Chemical Examination of Water from Ponds and Brooks in Westminster, made during an Investigation for an additional Water Supply for Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
8030	Oct. 9	Oct. 10	V. slight.	V. slight.	0.00	2.65	0.95	.0000	.0158	.0148	.0010	.14	.0030	.0000	0.5
8031	Oct. 9	Oct. 10	V. slight.	Slight.	0.30	3.30	1.25	.0262	.0154	.0136	.0018	.16	.0070	.0002	0.8
8178	Oct. 29	Oct. 30	V. slight.	Slight.	0.30	3.40	1.70	.0000	.0094	.0078	.0016	.13	.0020	.0000	0.6
8179	Oct. 29	Oct. 30	V. slight.	Slight.	0.03	2.65	0.85	.0016	.0128	.0096	.0032	.14	.0050	.0002	0.8
8180	Oct. 29	Oct. 30	Slight.	Slight.	0.08	3.00	1.10	.0000	.0072	.0060	.0012	.13	.0070	.0000	0.8

Odor of No. 8030, none; of all others, faintly vegetable. Nos. 8178 and 8179 were also grassy.—— No. 8030 was collected from Meeting-house Pond near the outlet. No. 8031 was collected from Wyman's dam at Wachusett village. No. 8178 was collected from the first stream, and No. 8180 from the second stream north-west of Wachusett Pond where these streams cross the road leading from Wachusett Pond to Meeting-house Pond. No 8179 was collected from Wachusett Pond.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Oct.	1891. Oct.	1891. Oct.	1891. Oct.	1891. Oct.
Day of examination,	10	10	31	31	31
Number of sample,	8030	8031	8178	8179	8180
PLANTS.					
Diatomaceæ,	2	7	1	1	2
Cyclotella,	0	0	0	1	0
Melosira,	2	1	0	0	pr.
Navicula,	pr.	0	1	pr.	1
Synedra,	pr.	1	0	pr.	0
Tabellaria,	0	5	0	0	1
Cyanophyceæ,	0	72	0	8	pr.
Chroöcoccus,	0	3	0	0	0
Cœlosphærium,	0	66	0	0	pr.
Microcystis,	0	1	0	8	0
Nostoc,	0	2	0	0	0
Algæ,	8	16	pr.	4	1
Chlorococcus,	0	16	pr.	3	0
Closterium,	0	0	0	0	1
Raphidium,	0	0	0	1	0
Scenedesmus,	8	0	0	0	0

FITCHBURG.

Microscopical Examination of Water from Ponds and Brooks in Westminster, made during an Investigation for an additional Water Supply for Fitchburg — Concluded.

[Number of organisms per cubic centimeter.]

	1891.				
	Oct.	Oct.	Oct.	Oct.	Oct.
PLANTS — Con.					
Fungi,	0	pr.	36	2	4
Crenothrix,	0	pr.	36	2	2
Molds,	0	0	0	0	2
ANIMALS.					
Infusoria. Monas,	0	1	0	0	0
Miscellaneous. Zoöglœa,	1	0	3	7	46
TOTAL,	11	96	40	22	55

WATER SUPPLY OF FOXBOROUGH WATER SUPPLY DISTRICT, FOXBOROUGH.

Description of Works. — Population of the town in 1890, 2,933. The works are owned by the Foxborough Water Supply District, and water was introduced Dec. 22, 1891. The source of supply is a system of tubular wells located north-east of the village of Foxborough, between Mechanic Street and the Neponset Reservoir, and not far from Chestnut Street. The system consists of 24 two-inch tubular wells varying in depth from 30 to 56 feet. Water is pumped from the wells to the town and to a covered iron tank 20 feet in diameter and 120 feet in height. Distributing mains are of cast iron. Service pipes are of wrought iron lined with cement.

Chemical Examination of Water from the Tubular Wells of the Foxborough Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8237	Nov. 9	Nov. 10	None.	None.	0.0	4.90	.0000	.0000	.37	.0500	.0000	0.6

Odor, none. —— The sample was collected while pumping from 24 wells.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 1; *Tabellaria*, pr. Total, 1.

WATER SUPPLY OF FRAMINGHAM. — FRAMINGHAM WATER COMPANY.

Chemical Examination of Water from the Filter-Gallery of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
6863	Jan. 1	Jan. 2	None.	None.	0.00	6.30	.0026	.0028	.57	.0880	.0000	3.1
6961	Feb. 2	Feb. 3	None.	None.	0.00	6.35	.0032	.0018	.60	.0400	.0001	2.9
7068	Mar. 2	Mar. 3	None.	None.	0.00	6.00	.0012	.0006	.52	.0700	.0000	3.1
7159	Apr. 3	Apr. 4	None.	None.	0.00	6.65	.0022	.0016	.65	.1250	.0001	3.0
7269	May 4	May 5	V. slight.	V. slight.	0.00	5.00	.0022	.0026	.63	.0700	.0001	2.6
7374	June 1	June 2	Slight, milky.	Slight.	0.02	6.20	.0026	.0104	.61	.1000	.0001	2.5
7511	July 1	July 2	V. slight.	V. slight.	0.00	6.05	.0026	.0034	.63	.0700	.0002	2.8
7747	Aug. 3	Aug. 4	Slight.	Slight.	0.00	6.35	.0022	.0046	.70	.0600	.0002	2.9
7879	Sept. 1	Sept. 2	V. slight.	None.	0.00	6.85	.0024	.0050	.65	.0500	.0001	3.2
7998	Oct. 1	Oct. 3	Slight.	V. slight.	0.02	6.40	.0034	.0044	.66	.0450	.0001	2.7
8193	Nov. 2	Nov. 3	V. slight.	None.	0.00	6.35	.0012	.0032	.64	.0600	.0000	2.7
8295	Dec. 2	Dec. 3	None.	V. slight.	0.00	6.50	.0018	.0022	.69	.0700	.0000	2.6
Av.	....	....	....	....	0.00	6.25	.0023	.0035	.63	.0707	.0001	2.8

Odor, none, excepting No. 7374, which was very faintly vegetable. —— The samples were collected from a faucet at the pumping station, while pumping. For analyses of water from Farm Pond, see page 80.

Microscopical Examination of Water from the Filter-Gallery of the Framingham Water Company.

[Number of organisms per cubic centimeter.]

	1891. Jan	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	4	5	6	12	2	2	5	2	3	3	3
Number of sample,	6863	6961	7068	7159	7269	7374	7511	7747	7879	7998	8193	8295
PLANTS.												
Diatomaceæ,	0	4	0	0	1	0	0	0	0	0	3	-
Asterionella,	0	0	0	0	0	0	0	0	0	0	0	-
Melosira,	0	4	0	0	0	0	0	0	0	0	0	-
Synedra,	0	0	0	0	1	0	0	0	0	0	3	-
Fungi,	8	3	36	0	122	382	520	171	42	144	77	-
Beggiatoa,	0	0	0	0	0	0	0	4	5	96	0	-
Cladothrix,	0	0	0	0	0	0	0	0	0	10	0	-
Crenothrix,	8	3	36	0	122	382	520	167	37	38	77	-
Miscellaneous. Zoöglœa,	0	9	0	0	106	150	4	46	48	68	18	-
TOTAL,	8	16	36	0	229	532	524	217	90	212	98	-

FITCHBURG.

Microscopical Examination of Water from Ponds and Brooks in Westminster, made during an Investigation for an additional Water Supply for Fitchburg — Concluded.

[Number of organisms per cubic centimeter.]

	1891.				
	Oct.	Oct.	Oct.	Oct.	Oct.
PLANTS — Con.					
Fungi,	0	pr.	36	2	4
Crenothrix,	0	pr.	36	2	2
Molds,	0	0	0	0	2
ANIMALS.					
Infusoria. Monas,	0	1	0	0	0
Miscellaneous. Zoöglœa,	1	0	3	7	46
TOTAL,	11	96	40	22	55

WATER SUPPLY OF FOXBOROUGH WATER SUPPLY DISTRICT, FOXBOROUGH.

Description of Works. — Population of the town in 1890, 2,933. The works are owned by the Foxborough Water Supply District, and water was introduced Dec. 22, 1891. The source of supply is a system of tubular wells located north-east of the village of Foxborough, between Mechanic Street and the Neponset Reservoir, and not far from Chestnut Street. The system consists of 24 two-inch tubular wells varying in depth from 30 to 56 feet. Water is pumped from the wells to the town and to a covered iron tank 20 feet in diameter and 120 feet in height. Distributing mains are of cast iron. Service pipes are of wrought iron lined with cement.

Chemical Examination of Water from the Tubular Wells of the Foxborough Water Supply District.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.	
	1891.											
8237	Nov. 9	Nov. 10	None.	None.	0.0	4.90	.0000	.0000	.37	.0500	.0000	0.6

Odor, none. —— The sample was collected while pumping from 24 wells.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 1; *Tabellaria*, pr. Total, 1.

FRAMINGHAM.

Water Supply of Framingham. — Framingham Water Company.

Chemical Examination of Water from the Filter-Gallery of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
6863	Jan. 1	Jan. 2	None.	None.	0.00	6.30	.0026	.0028	.57	.0880	.0000	3.1
6961	Feb. 2	Feb. 3	None.	None.	0.00	6.35	.0032	.0018	.60	.0400	.0001	2.9
7068	Mar. 2	Mar. 3	None.	None.	0.00	6.00	.0012	.0006	.52	.0700	.0000	3.1
7159	Apr. 3	Apr. 4	None.	None.	0.00	6.65	.0022	.0016	.65	.1250	.0001	3.0
7269	May 4	May 5	V. slight.	V. slight.	0.00	5.00	.0022	.0026	.63	.0700	.0001	2.6
7374	June 1	June 2	Slight, milky.	Slight.	0.02	6.20	.0026	.0104	.61	.1000	.0001	2.5
7511	July 1	July 2	V. slight.	V. slight.	0.00	6.05	.0026	.0034	.63	.0700	.0002	2.8
7747	Aug. 3	Aug. 4	Slight.	Slight.	0.00	6.35	.0022	.0046	.70	.0600	.0002	2.9
7879	Sept. 1	Sept. 2	V. slight.	None.	0.00	6.85	.0024	.0050	.65	.0500	.0001	3.2
7998	Oct. 1	Oct. 3	Slight.	V. slight.	0.02	6.40	.0034	.0044	.66	.0450	.0001	2.7
8193	Nov. 2	Nov. 3	V. slight.	None.	0.00	6.35	.0012	.0032	.64	.0600	.0000	2.7
8295	Dec. 2	Dec. 3	None.	V. slight.	0.00	6.50	.0018	.0022	.69	.0700	.0000	2.6
Av.	....	....	....	....	0.00	6.25	.0023	.0035	.63	.0707	.0001	2.8

Odor, none, excepting No. 7374, which was very faintly vegetable. —— The samples were collected from a faucet at the pumping station, while pumping. For analyses of water from Farm Pond, see page 80.

Microscopical Examination of Water from the Filter-Gallery of the Framingham Water Company.

[Number of organisms per cubic centimeter.]

	1891. Jan	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	4	5	6	12	2	2	5	2	3	3	3
Number of sample,	6863	6961	7068	7159	7269	7374	7511	7747	7879	7998	8193	8295
PLANTS.												
Diatomaceæ,	0	4	0	0	1	0	0	0	0	0	3	-
Asterionella,	0	0	0	0	0	0	0	0	0	0	0	-
Melosira,	0	4	0	0	0	0	0	0	0	0	0	-
Synedra,	0	0	0	0	1	0	0	0	0	0	3	-
Fungi,	8	3	36	0	122	382	520	171	42	144	77	-
Beggiatoa,	0	0	0	0	0	0	0	4	5	96	0	-
Cladothrix,	0	0	0	0	0	0	0	0	0	10	0	-
Crenothrix,	8	3	36	0	122	382	520	167	37	38	77	-
Miscellaneous. Zoöglœa,	0	9	0	0	106	150	4	46	48	68	18	-
Total,	8	16	36	0	229	532	524	217	90	212	98	-

FRAMINGHAM.

Chemical Examination of Water from the Underdrain beneath the Sewers at Framingham.

NOTE. — These analyses were made by the city of Boston.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.												
	Jan. 14	Jan. 15	Distinct.	Cons.	0.03	21.20	.1000	.0070	-	-	3.35	.5500	.0027	8.1
	Feb. 14	Feb. 16	Slight.	Slight.	0.02	19.70	.1050	.0030	-	-	3.40	.7000	.0015	7.9
	Mar. 14	Mar. 16	Slight.	Cons.	0.03	16.60	.0900	.0080	-	-	2.46	.5000	.0011	-
	Apr. 14	Apr. 15	V. slight.	Slight.	0.00	18.00	.1000	.0020	-	-	3.04	.5500	.0012	8.1
	May 14	May 15	V. slight.	Slight.	0.02	19.70	.1600	.0060	-	-	3.38	.5500	.0015	8.3
	June 14	June 16	Slight.	Cons.	0.00	20.60	.1450	.0070	-	-	3.65	.5500	.0017	7.6
	July 14	July 14	Slight.	Cons.	0.00	21.20	.0960	.0040	-	-	3.75	.3500	.0021	8.1
	Aug. 14	Aug. 15	V. slight.	Slight.	0.00	21.40	.0950	.0030	-	-	3.85	.5000	.0025	8.9
	Sept. 14	Sept. 15	Slight.	Slight.	0.02	21.80	.0920	.0020	-	-	3.85	.6000	.0023	8.1
	Oct. 14	Oct. 15	Slight.	Cons.	0.02	22.30	.0800	.0040	-	-	3.85	.5000	.0035	8.5
	Nov. 20	Nov. 23	Slight.	Cons.	0.00	22.00	.0720	.0040	-	-	3.85	.5000	.0016	7.3
	Dec. 14	Dec. 15	V. slight.	Cons.	0.00	20.80	.1000	.0040	-	-	3.75	.5500	.0018	7.4
Av.	....	....	....	....	0.01	20.44	.1029	.0045	-	-	3.51	.5833	.0019	8.0

Odor, generally faintly mouldy or musty. —— The samples were collected from the outlet of the underdrain on the northerly side of Waverley Street, near the pumping station.

Chemical Examination of Sewage from Framingham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
7204	Apr. 11	Apr. 13	Dec'd.	Heavy.	-	-	-	.4400	.1070	.0420	.0650	3.41	.0150	.1000	7.3
7502	June 30	July 1	Dec'd, milky.	Very heavy.	0.2	20.90	5.40	1.4000	.4200	.0800	.3400	2.58	.0070	.0002	-
7769	Aug. 10	Aug. 11	Dec'd.	Cons.	0.7	*40.00 35.70	*10.00 8.00	2.8800	.2960	.1110	.1870	5.63	.0050	.0000	5.4

The samples were collected as the sewage was flowing out upon the filter-beds. No. 7769 contained 660,800 bacteria per cubic centimeter.

* These determinations were made on sewage which had not been filtered through filter paper.

FRAMINGHAM.

Microscopical Examination of Sewage from Framingham.

[Number of organisms per cubic centimeter.]

	1891. April.	1891. July.	1891. August.
Day of examination,	16	2	12
Number of sample,	7204	7502	7769
PLANTS.			
Fungi,	**800**	**4,600**	**108**
Beggiatoa,	270	4,600	0
Fungus,	430	0	0
Saccharomyces,	100	0	0
Spirillum,	0	0	108
ANIMALS.			
Infusoria,	**247**	**950**	**204**
Monas,	230	600	96
Paramæcium,	7	100	108
Trachelocerca,	0	100	0
Trachelophyllum,	10	150	0
Vermes. Monocerca,	**0**	**50**	**0**
Miscellaneous. Zoöglœa,	**4,380**	**23,200**	**1,792**
Total,	5,427	28,850	2,104

Chemical Examination of Effluent from the Framingham Filter-Beds.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7205	Apr. 11	Apr. 13	None.	None.	0.0	-	-	.0152	.0018	-	-	1.80	.4000	.0021	2.6
7206	Apr. 11	Apr. 13	None.	V. slight.	0.0	-	-	.0760	.0030	-	-	1.80	.2200	.0005	3.2
7503	June 30	July 1	None.	V. slight.	0.0	19.80	-	.0160	.0044	-	-	3.00	1.0000	.0005	4.6
7504	June 30	July 1	None.	V. slight.	0.0	19.10	-	.0800	.0100	-	-	3.00	.9500	.0002	4.6
7505	June 30	July 1	None.	None.	0.0	7.40	-	.0000	.0006	-	-	1.20	.1250	.0000	1.8
7770	Aug. 10	Aug. 11	V. slight.	Cons., earthy.	0.0	7.20	-	.0000	.0034	-	-	1.22	.1100	.0000	1.7
7860	Aug. 25	Aug. 26	None.	None.	0.0	7.10	-	.0000	.0012	-	-	1.30	.1250	.0000	2.1

Odor of Nos. 7203 and 7206, faintly musty; of the others, none. —— The first four samples were collected at the outlets of the two underdrains, and the last three from a spring which existed before sewage was put upon the beds but which now receives also some of the sewage effluent, as may be seen by comparing the analyses of the water of the spring with the analyses of the unpolluted ground water of the region, given on the next page. Only a small portion of the sewage effluent is collected by the underdrains, and this, at the times when the samples were collected, soaked into the ground and was filtered a second time. No. 7770 contained 11 bacteria and No. 7860 four bacteria per cubic centimeter.

FRAMINGHAM.

Microscopical Examination of Effluent from the Framingham Filter-Beds.

[Number of organisms per cubic centimeter.]

	1891.						
	Apr.	Apr.	July.	July.	July.	Aug.	Aug.
Day of examination,	16	16	1	1	1	12	26
Number of sample,	7205	7206	7503	7504	7505	7770	7860
Zoöglœa,	3	5	1	1	2	114	2

Chemical Examination of Unpolluted Ground Water from a Flowing Tubular Well near the Framingham Filter-Beds.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7768	Aug. 10	Aug. 11	None.	Slight.	0.0	-	.0000	.0004	.22	.0100	.0000	1.3
7859	Aug. 25	Aug. 26	None.	None.	0.0	4.70	.0000	.0000	.17	.0100	.0000	1.9

Odor, none.——The samples were collected from a test well in the field on which the sewage of Framingham is disposed of by filtration. This well is, however, in a portion of the field not yet affected by the sewage. No. 7768 contained 56 bacteria and No. 7859 one bacterium per cubic centimeter.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Bannister Brook below the Framingham Filter-Beds.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7207	Apr. 11	Apr. 13	V. slight.	Slight.	1.0	-	-	.0018	.0160	.0140	.0020	.31	.0100	.0000	1.6
7858	Aug. 25	Aug. 26	Slight.	Cons., rusty.	1.7	7.75	3.25	.0032	.0322	.0300	.0022	.54	.0070	.0000	2.5

Odor of No. 7207, distinctly vegetable; of No. 7858, none.——The samples were collected from the brook at the first road crossing, below the field used as a place of sewage disposal by the town of Framingham. No. 7207 contained 337 and No. 7858 1,254 bacteria per cubic centimeter.

Microscopical Examination.

No. 7207. Diatomaceæ, *Diatoma*, 5; *Melosira*, 2; *Meridion*, 60; *Navicula*, 26; *Pinnularia*, 1; *Synedra*, 26; *Tabellaria*, 3. Algæ, *Closterium*, pr. Fungi, *Beggiatoa*, pr.; *Crenothrix*, 20. Infusoria, *Trachelomonas*, pr. Miscellaneous, *Zoöglœa*, 118. Total, 261.

No. 7858. Diatomaceæ, *Cymbella*, pr.; *Navicula*, 1. Algæ, *Staurastrum*, pr. Fungi, *Crenothrix*, 641. Infusoria, *Monas*, 1. Miscellaneous, *Zoöglœa*, 7. Total, 650.

GARDNER.

WATER SUPPLY OF GARDNER. — GARDNER WATER COMPANY.

Chemical Examination of Water from the Works of the Gardner Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7447	June 15	June 16	V. slight.	None.	0.02	2.85	0.85	.0000	.0132	.0108	.0024	.16	.0070	.0001	0.8
7448	June 15	June 16	V. slight.	V. slight.	0.02	2.85	0.85	.0008	.0130	.0110	.0020	.16	.0070	.0001	0.6
7449	June 15	June 16	None.	None.	0.03	3.15	0.85	.0012	.0094	.0076	.0018	.16	.0080	.0000	0.8

Odor of Nos. 7447 and 7448 faintly vegetable; of No. 7449 distinctly musty.——Nos. 7447 and 7448 were collected from the middle of Crystal Lake opposite the pumping-station, the former being collected from near the surface and the latter from near the bottom, the depth at this point being about fifteen feet. No. 7449 was collected from a tap near the dead end of a six-inch pipe on High Street.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. June.	1891. June.	1891. June.
Day of examination,	16	16	16
Number of sample,	7447	7448	7449
PLANTS.			
Diatomaceæ,	234	199	27
Asterionella,	48	44	1
Navicula,	0	pr.	0
Stephanodiscus,	186	154	19
Synedra,	0	1	7
Cyanophyceæ. Cœlosphærium,	3	pr.	0
Algæ,	3	18	0
Chlorococcus,	3	4	0
Botrycoccus,	0	0	0
Cosmarium,	0	0	0
Staurogenia,	0	14	0
ANIMALS.			
Rhizopoda,	1	0	0
Actinophrys,	1	0	0
Trachelomonas,	0	0	0
Miscellaneous. Zoöglœa,	0	44	0
TOTAL,	241	261	27

GLOUCESTER.

WATER SUPPLY OF GLOUCESTER — GLOUCESTER WATER COMPANY.

Chemical Examination of Water from Dike's Brook Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6879	Jan. 6	Jan. 7	V. slight.	V. slight.	0.65	5.80	1.10	.0002	.0202	.0174	.0028	.81	.0180	.0001	0.8
6980	Feb. 4	Feb. 5	V. slight.	V. slight.	0.45	3.95	1.45	.0048	.0190	.0168	.0022	.76	.0150	.0002	0.8
7090	Mar. 4	Mar. 5	None.	Slight.	0.40	3.90	2.00	.0006	.0146	.0116	.0030	.74	.0160	.0001	0.6
7192	Apr. 7	Apr. 8	V. slight.	V. slight.	0.30	3.40	1.05	.0000	.0124	.0106	.0018	.65	.0020	.0000	0.6
7287	May 6	May 7	V. slight.	V. slight.	0.30	2.90	1.30	.0000	.0152	.0112	.0040	.63	.0070	.0000	0.5
7388	June 3	June 4	V. slight.	V. slight.	0.25	3.55	1.25	.0000	.0126	.0092	.0034	.66	.0030	.0001	0.5
7536	July 7	July 7	Slight.	Slight.	0.50	4.55	1.40	.0056	.0178	.0150	.0028	.77	.0020	.0001	0.5
7779	Aug. 11	Aug. 11	V. slight.	V. slight.	0.70	4.35	1.45	.0000	.0188	.0162	.0026	.69	.0150	.0000	0.6
7899	Sept. 3	Sept. 4	Distinct.	Slight.	0.70	4.00	1.65	.0002	.0224	.0194	.0030	.73	.0050	.0000	0.5
8024	Oct. 7	Oct. 7	Slight.	V. slight.	0.70	4.65	2.00	.0002	.0332	.0238	.0094	.70	.0050	.0000	0.6
8208	Nov. 4	Nov. 4	Slight.	None.	0.40	4.05	1.65	.0000	.0234	.0194	.0040	.92	.0150	.0002	1.5
8305	Dec. 7	Dec. 8	V. slight.	V. slight.	0.40	4.20	1.50	.0004	.0256	.0210	.0046	.90	.0150	.0000	0.3
Av.	....	....	....	....	0.48	4.11	1.48	.0010	.0196	.0160	.0036	.75	.0098	.0001	0.6

Odor, generally vegetable or none, occasionally unpleasant; when heated generally vegetable, often disagreeable, sometimes none. —— The samples were collected from a faucet at the pumping station while pumping, with the exception of No. 7899, which was collected from the reservoir.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	5	7	10	12	4	8	12	5	8	5	9
Number of sample,	6879	6980	7090	7192	7287	7388	7536	7779	7899	8024	8208	8305
PLANTS.												
Diatomaceæ. Synedra,	0	0	1	0	3	pr.	0	0	6	0	4	320
Cyanophyceæ. Chroöcoccus,	0	0	0	0	0	0	0	85	2	0	1	0
Algæ,	0	32	21	66	4	7	11	8	17	0	pr.	1
Chlorococcus,	0	0	0	0	4	7	5	4	0	0	0	0
Closterium,	0	13	10	0	0	0	2	3	0	0	0	0
Palmella,	0	0	0	66	0	0	0	0	0	0	0	0
Protococcus,	0	11	9	0	0	0	0	0	0	0	0	0
Staurastrum,	0	0	0	0	0	0	4	1	17	0	0	0
Zoöspores,	0	8	2	0	0	0	0	0	0	0	pr.	1
Fungi. Crenothrix,	0	pr.	0	4	0	pr.	1,232	0	86	6	pr.	8

GLOUCESTER.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria,	3	62	78	pr.	6	0	0	4	2	pr.	21	16
Dinobryon,	0	4	0	pr.	6	0	0	0	0	0	0	0
Peridinium,	3	58	78	0	0	0	0	1	0	0	7	15
Trachelomonas,	0	0	0	0	0	0	0	3	2	pr.	14	1
Vermes. Anurea,	0	0	0	0	0	0	0	0	0	0	pr.	2
Miscellaneous. Zoöglœa,	0	0	34	114	190	3	0	38	318	20	0	44
TOTAL,	3	94	134	184	203	10	1,243	135	431	26	26	391

WATER SUPPLY OF GRAFTON. — GRAFTON WATER COMPANY.

An addition has been made to these works by sinking a tubular well 6 inches in diameter and 97 feet in depth, between the pumping station and the Quinsigamond River. This well was added to the works in 1889, but was not used until 1891. It is mostly in rock, only the upper 15 feet being in earth.

WATER SUPPLY OF GREAT BARRINGTON.

The works of the Great Barrington Water Company and of the Berkshire Heights Water Company have been purchased by the town.

WATER SUPPLY OF HAVERHILL.

The city of Haverhill purchased the works of the Haverhill Aqueduct Company in 1891.

HINSDALE.

Water Supply of Hinsdale Fire District, Hinsdale.

Chemical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7446	June 15	June 16	Distinct.	Cons.	0.40	2.65	1.25	.0018	.0216	.0162	.0054	.07	.0070	.0001	0.9
8181	Oct. 31	Nov. 2	V. slight.	V. slight.	1.10	3.35	1.90	.0206	.0290	.0244	.0046	.05	.0130	.0001	0.3

Odor of 7446, vegetable and mouldy; of 8181, none.——The samples were collected from a faucet in the village.

Microscopical Examination.

No. 7446. Diatomaceæ, *Diatoma*, 3. Algæ, *Chlorococcus*, 3. Fungi, *Crenothrix*, 20. Infusoria, *Dinobryon*, 288. *Trachelomonas*, 3. Vermes, *Anurea*, 3. Miscellaneous, *Zoöglœa*, 152. Total, 472.

No. 8181. Diatomaceæ, *Cyclotella*, 1. Algæ, *Closterium*, 14. Fungi, *Crenothrix*, 1,090. Miscellaneous, *Zoöglœa*, 5. Total, 1,110.

Water Supply of Holliston. — Holliston Water Company.

Description of Works. — Population in 1890, 2,619. The works are owned by the Holliston Water Company. Water was introduced about May 1, 1891. The source of supply is a large well situated in the valley of Jar Brook, in the village of East Holliston. The well is situated about 200 feet northwest of Washington Street, between that street and a mill-pond known as Talbot Pond. The total distance from the street to the pond is approximately 600 feet. The well is 26 feet in diameter and about 30 feet deep, and contains about 24 feet of water when not drawn upon. The lower 8 or 10 feet is in ledge. The well is covered. Water is pumped from the well to the distributing mains, the surplus going to an open iron tank, 30 feet in diameter and 60 feet in height. In 1890 the water company constructed a small storage reservoir on Jar Brook, between Talbot Pond and the well, the shore of the reservoir being at one point within 15 feet of the well. A pipe is laid from the reservoir to the well, so that water may be drawn from the reservoir when necessary. The greatest depth of the reservoir is about 8 feet and its bottom is cleared of soil and muck and covered with gravel. Distributing mains are of cast iron; service pipes are generally of lead, but a few are of iron.

HOLLISTON.

Chemical Examination of Water from the Well of the Holliston Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7867	Aug. 28	Aug. 29	V. slight, clayey.	Slight.	0.0	5.70	.0000	.0024	.25	.0100	.0000	1.7
7868	Aug. 28	Aug. 29	None.	None.	0.0	5.70	.0000	.0018	.24	.0120	.0000	1.9

Odor of No. 7867, none; of 7868, unpleasant.——Sample No. 7867 was collected from the well No. 7868 was collected from a faucet in a house three-fourths of a mile from the well.

Microscopical Examination.

No. 7867. Fungi, *Crenothrix*, 4.

Water Supply of Holyoke.

The additional storage reservoir on Whiting Street Brook, of which a general description is given in the special report upon the Examination of Water Supplies, 1890, page 153, was completed early in the fall of 1890 and filled during the succeeding winter and spring. Provision has been made for drawing water from this reservoir at the bottom through the waste gates, or from mid-depth through a pipe passing through the dam near its southerly end, or by means of a system of pipes laid beneath the bottom of the reservoir for the purpose of obtaining filtered water. In no case, however, is water taken directly from the reservoir to the city, but it flows into a small reservoir situated on the same brook, a short distance down the valley, from which a pipe leads to the city. The overflow from the storage reservoir also goes into this small reservoir. The pipe system beneath the reservoir is not now used.

HOLYOKE.

Chemical Examination of Water from Brooks which discharge into the Whiting Street Storage Reservoir, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6934	Jan. 20	Jan. 22	V. slight.	V. slight.	0.0	3.20	0.55	.0010	.0028	.0018	.0010	.09	.0100	.0000	1.9
7025	Feb. 16	Feb. 17	V. slight.	Cons.	0.0	3.45	0.50	.0000	.0046	.0010	.0036	.07	.0120	.0001	1.9
7133	Mar. 18	Mar. 19	None.	V. slight.	0.0	1.85	0.80	.0000	.0028	.0018	.0010	.10	.0050	.0000	0.8
7134	Mar. 18	Mar. 19	None.	Slight.	0.1	7.10	0.95	.0000	.0048	.0034	.0014	.13	.0130	.0000	4.2
7335	May 19	May 21	Slight.	Cons.	0.2	7.85	1.35	.0020	.0124	.0096	.0028	.10	.0030	.0000	4.3
7583	July 19	July 22	Slight.	Slight.	0.0	9.05	1.30	.0008	.0086	.0058	.0028	.10	.0180	.0001	4.9
7857	Aug. 24	Aug. 25	Slight, clayey.	Slight.	0.3	9.35	1.55	.0016	.0182	.0122	.0060	.12	.0070	.0001	5.0
7135	Mar. 18	Mar. 19	None.	Slight.	0.0	4.75	0.60	.0000	.0020	.0014	.0006	.12	.0110	.0000	3.0

Odor of Nos. 7025, 7133 and 7134, none; of the others, faintly vegetable; the odor generally disappears on heating. —— The first three were collected from the brook which enters the reservoir from the north; the next four from the brook entering from the south, and the last one from the brook entering from the west.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Mar.	May.	July.	Aug.	Mar.
Day of examination,	22	18	20	20	21	22	25	20
Number of sample,	6934	7025	7133	7134	7335	7583	7857	7135
PLANTS.								
Diatomaceæ,	**0**	**60**	**5**	**48**	**14**	-	**0**	**32**
Melosira,	0	0	0	0	0	-	0	0
Meridion,	0	18	0	32	2	-	0	26
Navicula,	0	36	1	11	5	-	0	5
Nitzschia,	0	0	0	2	0	-	0	1
Pinnularia,	0	4	0	0	0	-	0	0
Synedra,	0	2	4	3	7	-	0	0
Tabellaria,	0	0	0	0	0	-	0	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	-	**0**	**0**
Anabæna,	0	0	0	0	0	-	0	0
Microcystis,	0	0	0	0	0	-	0	0
Nostoc spores,	0	0	0	0	0	-	0	0
Algæ,	**0**	**0**	**0**	**0**	**0**	-	**1**	**0**
Chlorococcus,	0	0	0	0	0	-	1	0
Pandorina,	0	0	0	0	0	-	0	0
Pediastrum,	0	0	0	0	0	-	0	0
Fungi. Crenothrix,	**0**	**0**	**0**	pr.	**3**	-	**0**	pr.

HOLYOKE.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.							
	Jan.	Feb.	Mar.	Mar.	May.	July.	Aug.	Mar.
ANIMALS.								
Infusoria,	12	0	0	0	0	-	1	0
Peridinium,	12	0	0	0	0	-	1	0
Trachelomonas,	0	0	0	0	0	-	pr.	0
Miscellaneous. Zoöglœa,	35	1,258	3	21	72	-	0	9
TOTAL,	47	1,318	8	69	89	-	2	41

Chemical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1890.														
6837	Dec. 17	Dec. 18	V. slight.	Slight.	0.30	6.95	1.60	.0008	.0244	.0188	.0056	.15	.0120	.0000	3.6
	1891.														
6935	Jan. 20	Jan. 22	V. slight.	Slight.	0.50	8.30	1.80	.0030	.0216	.0202	.0014	.15	.0100	.0001	4.6
7026	Feb. 16	Feb. 17	V. slight.	Slight.	0.33	8.50	2.15	.0054	.0236	.0174	.0062	.16	.0090	.0003	3.9
7136	Mar. 18	Mar. 19	V. slight.	None.	0.05	2.95	1.40	.0014	.0112	.0096	.0016	.08	.0100	.0000	1.3
7235	Apr. 21	Apr. 22	Slight.	V. slight.	0.08	3.80	0.80	.0000	.0158	.0098	.0060	.12	.0060	.0000	2.5
7336	May 19	May 21	Slight.	Cons.	0.10	4.80	1.35	.0000	.0186	.0122	.0064	.08	.0020	.0000	2.6
7460	June 17	June 18	Distinct.	Slight.	0.15	5.10	1.35	.0016	.0220	.0188	.0032	.16	.0000	.0000	2.6
7584	July 19	July 22	Decided.	Cons.	0.30	6.00	2.10	.0044	.0430	.0272	.0158	.12	.0050	.0000	3.0
7856	Aug. 24	Aug. 25	None.	V. slight.	0.65	6.40	2.35	.0248	.0416	.0402	.0014	.12	.0050	.0001	3.3
7983	Sept. 15	Sept. 16	Slight.	Cons.	0.70	8.20	3.25	.0460	.0504	.0396	.0108	.13	.0100	.0050	4.0
8086	Oct. 14	Oct. 15	V. slight.	Slight.	0.90	7.95	3.00	.0400	.0430	.0352	.0078	.11	.0100	.0001	3.2
8247	Nov. 10	Nov. 11	V. slight.	V. slight.	0.70	6.90	2.20	.0212	.0538	.0470	.0068	.12	.0550	.0005	3.2
8337	Dec. 15	Dec. 16	V. slight.	V. slight.	0.50	7.20	2.80	.0016	.0284	.0260	.0024	.13	.1000	.0005	3.2
Av.	....	....	....	....	0.40	6.39	2.01	.0116	.0306	.0248	.0058	.13	.0180	.0005	3.2

Odor, generally vegetable, sometimes none; occasionally very disagreeable. On heating, it is generally vegetable and frequently disagreeable.——The samples were collected from the reservoir and generally from the pipe which takes water from it at mid-depth. No. 7136 was collected at the surface, near the gate-house.

HOLYOKE.

Microscopical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Number of organisms per cubic centimeter.]

	1890.	1891.											
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	22	18	20	23	21	18	23	25	16	15	12	17
Number of sample,	6837	6935	7026	7136	7235	7336	7460	7584	7856	7933	8086	8247	8337
PLANTS.													
Diatomaceæ,	**16**	**2**	**4**	**0**	**952**	**299**	**1**	**0**	**0**	**2**	**1**	**pr.**	**0**
Cyclotella,	0	0	0	0	832	0	0	0	0	0	0	0	0
Diatoma,	0	0	0	0	9	3	1	0	0	0	0	0	0
Melosira,	0	2	0	0	5	0	0	0	0	0	0	0	0
Synedra,	16	0	4	0	106	296	0	0	0	2	1	pr.	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2,562**	**0**	**0**	**6**	**0**	**0**
Anabæna,	0	0	0	0	0	0	0	1,728	0	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	0	0	0	0	6	0	0
Nostoc spores,	0	0	0	0	0	0	0	834	0	0	0	0	0
Algæ,	**168**	**0**	**18**	**0**	**0**	**0**	**61**	**19**	**0**	**0**	**326**	**0**	**0**
Chlorococcus,	0	0	18	0	0	0	60	10	0	0	0	0	0
Pandorina,	0	0	0	0	0	0	1	9	0	0	0	0	0
Protococcus,	168	0	0	0	0	0	0	0	0	0	0	0	0
Raphidium,	0	0	0	0	0	0	0	0	0	0	326	0	0
Fungi,	**2**	**22**	**24**	**0**	**42**	**12**	**1**	**0**	**pr.**	**327**	**3**	**1**	**1**
Crenothrix,	2	22	24	0	42	12	1	0	pr.	20	3	1	1
Leptothrix,	0	0	0	0	0	0	0	0	0	307	0	0	0
ANIMALS.													
Infusoria,	**45**	**0**	**1**	**0**	**9**	**11**	**21**	**1**	**0**	**2**	**0**	**0**	**0**
Dinobryon,	0	0	0	0	8	0	21	0	0	0	0	0	0
Monas,	0	0	pr.	0	1	0	0	1	0	0	0	0	0
Peridinium,	0	0	1	0	0	3	pr.	0	0	2	0	0	0
Synura,	45	0	0	0	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	8	0	0	0	0	0	0	0
Crustacea,	**0**	**pr.**	**0**	**0**	**pr.**	**pr.**	**pr.**	**0**	**0**	**pr.**	**pr.**	**0**	**0**
Cyclops,	0	pr.	0	0	pr.	pr.	pr.	0	0	pr.	pr.	0	0
Daphnia,	0	0	0	0	0	0	0	0	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	**9**	**60**	**32**	**8**	**64**	**298**	**6**	**273**	**0**	**92**	**128**	**5**	**26**
TOTAL,	240	84	79	8	1,067	620	90	2,855	0	423	464	6	27

HOLYOKE.

Chemical Examination of Water from Tannery Brook, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7585	July 19	July 22	Slight.	Cons.	0.0	7.75	1.25	.0020	.0074	.0072	.0002	.10	.0090	.0001	4.6

Odor, very faintly vegetable. —— The sample was collected from the brook.

Microscopical Examination.

Diatomaceæ, *Cocconeis*, 1; *Diatoma*, pr.; *Fragilaria*, 12; *Melosira*, 12; *Navicula*, 6, *Synedra*, 6; *Tabellaria*, pr. Algæ, *Raphidium*, 2. Fungi, *Crenothrix*, 2. Infusoria, *Glenodinium*, pr. Miscellaneous, *Zoöglœa*, 418. Total, 459.

Chemical Examination of Water from Wright and Ashley Ponds, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7586	July 19	July 22	Distinct.	Slight.	0.00	5.20	-	.0048	.0248	.0242	.0006	.14	.0070	.0000	2.7
8085	Oct. 14	Oct. 15	Slight.	Cons.	0.02	7.00	1.85	.0044	.0238	.0160	.0078	.11	.0000	.0001	3.0

Odor, vegetable. —— Sample No. 7586 was collected from Ashley Pond; No. 8085 from Wright Pond.

Microscopical Examination.

No. 7586. Diatomaceæ, *Cyclotella*, pr.; *Diatoma*, pr.; *Synedra*, 3; *Tabellaria*, pr. Cyanophyceæ, *Chroöcoccus*, 46; *Clathrocystis*, 6; *Microcystis*, 34; *Nostoc*, 1. Algæ, *Chlorococcus*, 12; *Pandorina*, pr.; *Scenedesmus*, pr. Fungi, *Molds*, pr. Infusoria, *Monas*, 2; *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 194. Total, 299.

No. 8085. Diatomaceæ, *Asterionella*, 13; *Cyclotella*, pr.; *Fragilaria*, 8; *Melosira*, 11. Cyanophyceæ, *Anabæna*, 7; *Clathrocystis*, 10; *Microcystis*, 26. Algæ, *Closterium*, 2. Infusoria, *Trachelomonas*, 5. Miscellaneous, *Zoöglœa*, 248. Total, 330.

Water Supply of Hopkinton.

A fourth tubular well, 8 inches in diameter and 119 feet deep, was added to these works in 1889. The original wells are located in a straight line, 130 feet apart, and the new well is half way between two of them. All of the wells are sunk in rock, which is but nine feet below the surface.

HUDSON.

WATER SUPPLY OF HUDSON.

Chemical Examination of Water from Gates Pond, Berlin.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6896	Jan. 14	Jan. 15	V. slight.	V. slight.	0.00	2.30	0.55	.0056	.0102	.0090	.0012	.25	.0400	.0000	1.1
7005	Feb. 13	Feb. 13	V. slight.	None.	0.03	1.95	0.80	.0026	.0086	.0044	.0042	.12	.0090	.0001	0.5
7115*	Mar. 11	Mar. 13	V. slight.	None.	0.00	0.95	0.45	.0040	.0040	.0030	.0010	.10	.0250	.0000	0.2
7215	Apr. 14	Apr. 15	Slight.	Slight.	0.02	2.90	0.75	.0004	.0140	.0120	.0020	.17	.0050	.0000	1.1
7307	May 12	May 13	Slight.	Slight.	0.05	2.80	0.75	.0000	.0126	.0104	.0022	.22	.0020	.0000	1.4
7417	June 9	June 10	V. slight.	V. slight.	0.02	2.60	0.75	.0000	.0142	.0098	.0044	.19	.0050	.0000	1.1
7564	July 15	July 16	Distinct.	Slight.	0.10	2.60	0.95	.0000	.0178	.0140	.0038	.20	.0050	.0000	0.8
7801	Aug. 13	Aug. 13	Slight.	Slight.	0.00	2.95	1.05	.0000	.0174	.0134	.0040	.22	.0000	.0000	0.6
7918	Sept. 11	Sept. 11	V. slight.	Slight.	0.00	2.50	0.80	.0000	.0170	.0120	.0050	.22	.0030	.0000	0.6
8051	Oct. 13	Oct. 14	Distinct.	Slight.	0.05	2.40	1.00	.0000	.0172	.0124	.0048	.20	.0050	.0000	0.9
8210	Nov. 4	Nov. 4	Slight.	Cons.	0.08	2.60	1.50	.0026	.0222	.0202	.0020	.23	.0050	.0000	0.8
8323	Dec. 11	Dec. 11	V. slight.	V. slight.	0.05	2.15	1.00	.0004	.0138	.0110	.0028	.20	.0020	.0000	0.6
Av.	....	....	....	....	0.04	2.52	0.90	.0011	.0150	.0117	.0033	.20	.0074	.0000	0.9

Odor, vegetable or none, frequently mouldy or unpleasant.——The samples were collected from the pond.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	19	14	12	16	13	10	16	14	12	14	5	12
Number of sample, ...	6896	7005	7115	7215	7307	7417	7564	7801	7918	8051	8210	8323
PLANTS.												
Diatomaceæ, ...	**10**	**16**	**0**	**353**	**89**	**12**	**21**	**2**	**23**	**13**	**372**	**276**
Asterionella, ...	4	0	0	280	24	0	0	0	0	0	2	8
Fragilaria, ...	0	0	0	0	0	0	0	0	0	0	5	3
Melosira, ...	4	0	0	16	17	4	16	0	1	4	358	212
Synedra, ...	2	16	0	52	0	pr.	1	2	22	9	6	44
Tabellaria, ...	0	0	0	5	48	8	4	pr.	pr.	0	1	9

* This sample probably contained a large amount of water from melting snow or ice, and it has not been included in making up the average.

HUDSON.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	**0**	**0**	**0**	**5**	**0**	**7**	**102**	**13**	**288**	**49**	**20**	**6**
Chroöcoccus,	0	0	0	5	0	0	54	0	216	0	pr.	4
Cœlosphærium,	0	0	0	0	0	0	0	0	pr.	7	0	0
Microcystis,	0	0	0	0	0	7	48	13	72	42	20	2
Algæ,	**pr.**	**0**	**0**	**153**	**4**	**73**	**418**	**0**	**28**	**1**	**21**	**4**
Botrycoccus,	0	0	0	pr.	0	27	0	0	0	0	0	pr.
Chlorococcus,	0	0	0	0	4	37	410	0	15	1	18	4
Conferva,	pr.	0	0	1	0	5	1	0	pr.	0	0	pr.
Hyalotheca,	0	0	0	0	0	0	0	0	7	0	0	0
Palmella,	0	0	0	152	0	0	0	0	0	0	0	0
Raphidium,	0	0	0	0	0	4	4	0	5	0	0	0
Staurastrum,	0	0	0	0	0	pr.	3	0	1	pr.	3	0
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**1**	**pr.**	**0**	**0**	**0**	**6**	**2**
Infusoria,	**4**	**2**	**pr.**	**54**	**22**	**6**	**58**	**35**	**46**	**41**	**54**	**124**
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	4	0
Dinobryon,	4	0	0	0	4	0	22	0	45	27	17	17
Dinobryon cases,	0	0	0	0	0	6	0	0	0	0	25	104
Euglena,	0	0	0	0	0	0	0	0	0	3	0	0
Monas,	0	0	0	0	0	0	0	7	1	pr.	pr.	pr.
Peridinium,	pr.	1	pr.	54	18	0	2	28	0	0	pr.	2
Synura,	0	0	0	0	0	0	34	0	0	10	7	1
Trachelomonas,	0	1	0	0	0	0	pr.	pr.	0	1	1	0
Vermes. Anurea,	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**pr.**
Crustacea,	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**pr.**	**0**
Cyclops,	0	pr.	0	0	0	0	0	0	pr.	0	pr.	0
Daphnia,	0	0	0	0	0	0	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	**20**	**52**	**3**	**268**	**72**	**9**	**0**	**2**	**142**	**38**	**198**	**7**
TOTAL,	34	70	3	833	187	108	599	52	527	142	671	419

HUNTINGTON.

Chemical Examination of Water from a Spring in Huntington.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7170	Apr. 2	Apr. 4	None.	None.	0.03	2.30	.0000	.0012	.08	.0050	.0000	0.8

Odor, none.—— The sample was collected from a faucet in the village of Huntington. The water comes from a spring which is used as a source of water supply by 43 families in the village.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 1. Fungi, *Crenothrix*, 2. Total, 3.

WATER SUPPLY OF HYDE PARK. — HYDE PARK WATER COMPANY.

Since 1887 68 tubular wells have been added to the works, making a total of 132 in use in 1891.

On account of the trouble caused by growths of algæ in the water stored in the open reservoir a covered iron tank 50 feet in diameter and 35 feet in height was built in 1890. Water enters the tank at the top and flows out at the bottom. The open reservoir is not now used, but is kept full and held in reserve for emergencies.

Chemical Examination of Water from the Tubular Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7493	June 26	June 26	None.	None.	0.00	8.00	.0000	.0028	.80	.0900	.0002	3.5
7881	Sept. 1	Sept. 2	None.	None.	0.05	10.20	.0000	.0052	1.12	.0450	.0002	3.6

Odor of 7493, none; of 7881, faintly vegetable.—— The samples were collected from a faucet in the pumping station.

Microscopical Examination.

No. 7493. Diatomaceæ, *Cymbella*, pr. No. 7881. Fungi, *Crenothrix*, 92; *Micrococcus*, 406. Total, 498.

HYDE PARK.

Chemical Examination of Water from the Distributing Reservoir of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7880	Sept. 1	Sept. 2	Dec'd.	Cons.	0.10	8.55	2.85	.0000	.0344	.0140	.0204	.84	.0000	.0003	3.8

Odor, vegetable.——The sample was collected from the reservoir near the gate-house. No water had been drawn from the reservoir for four months previous to the collection of the sample, and only enough was pumped into it to supply the loss by evaporation and leakage. The overflow from the new covered tank runs into the reservoir, and in case the tank should become empty an arrangement has been made by which the supply would come from the reservoir automatically.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 2; *Fragilaria*, 32; *Navicula*, 1. Cyanophyceæ, *Chroöcoccus*, 8,519; *Polyedrium*, 1; *Scenedesmus*, 1; *Staurastrum*, 100. Fungi, *Crenothrix*, 1. Infusoria, *Ciliated infusorian*, 4; *Cryptomonas*, 1; *Peridinium*, 3. Vermes, *Anuræa*, 3; *Rotatorian ova*, 2. Miscellaneous, *Zoöglœa*, 224. Total, 8,894.

Chemical Examination of Water from the Covered Tank of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7882	Sept. 1	Sept. 2	None.	None.	0.0	9.30	.0018	.0034	1.10	.0400	.0002	3.6

Odor, none.——The sample was collected from the tank four feet beneath the surface.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2. Algæ, *Raphidium*, 1. Fungi, *Crenothrix*, 43. Rhizopoda, *Arcella*, pr. Miscellaneous, *Zoöglœa*, 9. Total, 55.

Water Supply of Kingston.

The works for collecting water until recently consisted of a well with a short filter-gallery running from it, parallel with and not far from a mill pond on Jones River. In 1891 the filter-gallery was lowered and extended to a distance of 1,280.5 feet from the well. The general cross section of the gallery is 20 inches wide with side walls 18 inches high and an arched roof. In two places, covering a

KINGSTON.

total length of 189 feet 8 inches, 10-inch pipe was laid; 128 feet 8 inches of this was laid at a place where quicksand was encountered and the remaining 61 feet extends from a sand chamber at the end of the filter-gallery to the large well from which water is pumped. The distance from the edge of the mill pond to the new gallery is generally between 15 and 50 feet.

LAKEVILLE.

For chemical and microscopical examinations of water from Long, Assawompsett and Elder's ponds in Lakeville, see *Taunton*.

WATER SUPPLY OF LANCASTER.

(See *Clinton*.)

WATER SUPPLY OF LAWRENCE.*

Chemical Examination of Water from the Merrimack River above Lawrence, at the Intake of the Lawrence Water Works, collected one foot beneath the surface.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1891.														
6926	Jan. 20	Jan. 21	V. slight.	V. slight.	0.40	4.00	1.45	.0022	.0148	.0132	.0016	.13	.0200	.0001	0.9
7029	Feb. 17	Feb. 18	Slight.	V. slight.	0.30	3.25	1.25	.0002	.0102	.0086	.0016	.10	.0240	.0001	1.4
7237	Apr. 21	Apr. 22	Decided.	Heavy, earthy.	0.25	2.70	0.90	.0000	.0088	.0060	.0028	.10	.0070	.0000	0.9
7331	May 19	May 20	Distinct.	Heavy.	0.30	3.10	1.30	.0004	.0138	.0114	.0024	.11	.0070	.0000	0.9
7462	June 17	June 18	Slight.	Cons., rusty.	0.25	4.05	1.40	.0050	.0208	.0146	.0062	.15	.0050	.0002	1.3
7580	July 21	July 22	Slight.	Cons.	0.25	4.10	1.15	.0080	.0200	.0124	.0076	.16	.0120	.0002	1.1
7836	Aug. 19	Aug. 20	V. slight.	Slight.	0.15	3.55	1.25	.0060	.0156	.0120	.0036	.16	.0030	.0002	1.1
7940	Sept. 15	Sept. 16	Slight.	Slight.	0.20	4.75	2.15	.0066	.0158	.0132	.0026	.23	.0100	.0002	1.6
8162	Oct. 22	Oct. 23	Distinct, milky	Cons.	0.20	4.00	1.30	.0050	.0162	.0144	.0018	.26	.0090	.0001	1.7
8257	Nov. 11	Nov. 11	Slight.	Slight.	0.20	3.90	1.00	.0088	.0190	.0160	.0030	.32	.0150	.0001	1.6
8341	Dec. 16	Dec. 17	Slight.	Cons.	0.40	4.30	1.40	.0014	.0126	.0110	.0016	.21	.0090	.0003	1.3
Av..	....	....	....	....	0.27	3.79	1.32	.0040	.0152	.0121	.0031	.18	.0110	.0001	1.3

Odor, generally musty, frequently vegetable; occasionally none.——The samples were collected from the middle of the river opposite the pumping station of the Lawrence Water Works. For a record of the amount of water flowing in the river on the dates when these samples were collected, see page 146. For additional analyses of water from the river, see *Merrimack River*, in the chapter headed "Rivers."

* In addition to the analyses given here, other analyses of the Lawrence water supply, made at the Lawrence Experiment Station, will be found in a subsequent portion of this report.

LAWRENCE.

Microscopical Examination of Water from the Merrimack River above Lawrence, at the Intake of the Lawrence Water Works, collected one foot beneath the surface.

[Number of organisms per cubic centimeter.]

	1891.										
	Jan.	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . . .	22	20	23	21	18	22	20	17	23	13	18
Number of sample, . . .	6926	7029	7237	7331	7462	7580	7836	7940	8162	8257	8341
PLANTS.											
Diatomaceæ, ...	**1**	**1**	**4**	**98**	**59**	**165**	**141**	**41**	**8**	**11**	**13**
Asterionella, ...	1	0	0	8	2	0	4	4	6	4	5
Diatoma, ...	0	0	0	0	4	0	1	0	0	0	0
Melosira, ...	0	0	0	37	0	10	0	3	0	0	3
Navicula, ...	0	pr.	pr.	1	pr.	1	17	1	pr.	1	1
Synedra, ...	pr.	1	4	42	41	139	66	32	1	6	4
Tabellaria, ...	pr.	0	0	10	12	15	53	1	1	0	0
Cyanophyceæ. Chroöcoccus,	**0**	**0**	**0**	**0**	**0**	**50**	**0**	**2**	**0**	**0**	**0**
Algæ, ...	**0**	**0**	**0**	**pr.**	**16**	**12**	**501**	**34**	**12**	**pr.**	**0**
Chlorococcus, ...	0	0	0	0	16	4	498	13	10	pr.	0
Conferva, ...	0	0	0	pr.	0	0	0	5	0	0	0
Raphidium, ...	0	0	0	0	0	4	2	16	2	0	0
Scenedesmus, ...	0	0	0	0	pr.	4	1	0	pr.	pr.	0
Fungi, ...	**2**	**54**	**5**	**3**	**32**	**35**	**1**	**2**	**6**	**22**	**6**
Crenothrix, ...	2	54	5	3	32	35	1	2	pr.	22	6
Molds, ...	0	0	0	0	0	0	0	0	6	0	0
ANIMALS.											
Infusoria, ...	**0**	**pr.**	**pr.**	**0**	**12**	**58**	**33**	**pr.**	**17**	**1**	**0**
Ciliated infusorian, ...	0	0	0	0	2	0	0	0	0	0	0
Dinobryon, ...	0	0	0	0	0	56	32	0	16	pr.	0
Monas, ...	0	pr.	pr.	0	0	0	0	0	1	1	0
Peridinium, ...	0	pr.	0	0	0	2	1	0	0	0	0
Trachelomonas, ...	0	0	0	0	1	0	0	pr.	0	pr.	0
Vorticella, ...	0	0	0	0	9	0	pr.	0	0	0	0
Vermes. Anuræa, ...	**0**	**0**	**0**	**0**	**pr.**	**0**	**2**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa, . .	**520**	**112**	**0**	**13**	**31**	**248**	**0**	**538**	**282**	**190**	**86**
TOTAL, ...	523	167	9	114	150	568	678	617	325	224	105

LAWRENCE.

Chemical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6927	Jan. 20	Jan. 21	V. slight.	Slight.	0.35	3.60	1.15	.0016	.0150	.0134	.0016	.10	.0300	.0001	1.3
7030	Feb. 17	Feb. 18	V. slight.	V. slight.	0.30	3.40	1.10	.0024	.0114	.0092	.0022	.12	.0260	.0002	1.3
7131	Mar. 17	Mar. 18	Slight, milky.	Heavy, earthy.	0.30	2.85	1.15	.0000	.0116	.0084	.0032	.06	.0250	.0001	1.1
7238	Apr. 21	Apr. 22	Dec'd.	Heavy, earthy.	0.20	2.90	1.15	.0000	.0080	.0052	.0028	.08	.0220	.0000	0.9
7332	May 19	May 20	Distinct.	Heavy.	0.30	3.20	1.15	.0014	.0156	.0130	.0026	.10	.0120	.0001	0.9
7463	June 17	June 18	Distinct.	Cons.	0.30	3.70	1.70	.0044	.0218	.0160	.0058	.18	.0090	.0002	1.3
7582	July 21	July 22	Distinct.	Cons., earthy.	0.30	3.90	1.65	.0084	.0212	.0170	.0042	.19	.0150	.0001	0.9
7834	Aug. 19	Aug. 20	Slight.	Slight.	0.15	3.90	1.30	.0062	.0134	.0098	.0036	.17	.0120	.0003	1.4
7939	Sept. 15	Sept. 16	Slight.	Cons.	0.18	4.50	2.05	.0058	.0152	.0128	.0024	.21	.0100	.0002	0.8
8163	Oct. 22	Oct. 23	Distinct, milky.	Cons.	0.25	4.30	2.10	.0060	.0198	.0138	.0060	.25	.0070	.0003	1.6
8258	Nov. 11	Nov. 12	Distinct.	Heavy, earthy.	0.12	4.65	1.10	.0090	.0170	.0144	.0026	.35	.0200	.0002	1.6
8342	Dec. 16	Dec. 17	Distinct.	Slight.	0.43	4.60	1.55	.0012	.0114	.0098	.0016	.21	.0100	.0003	1.4
Av.	....	....	....	....	0.26	3.79	1.43	.0039	.0151	.0119	.0032	.17	.0165	.0002	1.2

Odor, generally distinctly musty, occasionally none, sometimes vegetable on heating. —— The samples were collected from a faucet in the check-valve just beyond the pump, and represent a mixture of water from the river and the filter-gallery, though but a small part of the water comes from the latter source.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	22	20	20	23	21	18	22	20	17	23	13	18
Number of sample,	6927	7030	7131	7238	7332	7463	7582	7834	7939	8163	8258	8342
PLANTS.												
Diatomaceæ,	**6**	**3**	**4**	**3**	**66**	**81**	**5**	**112**	**47**	**11**	**77**	**7**
Asterionella,	0	1	0	0	0	2	0	1	4	1	2	2
Fragilaria,	0	0	0	0	0	0	0	13	8	6	5	0
Melosira,	0	1	0	0	10	pr.	0	0	0	1	4	0
Navicula,	2	0	0	0	1	1	pr.	37	1	0	24	pr.
Nitzschia,	3	0	4	0	0	0	5	0	0	0	0	0
Synedra,	1	1	0	3	54	70	0	46	29	1	42	3
Tabellaria,	0	0	0	0	1	8	0	15	5	2	pr.	2
Algæ. Chlorococcus,	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**66**	**17**	pr.	**0**	**0**
Fungi. Crenothrix,	**7**	**70**	**6**	pr.	**16**	**23**	**0**	pr.	**2**	**3**	**82**	**24**

LAWRENCE.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria,	0	pr.	0	0	1	0	0	3	pr.	pr.	1	0
Monas,	0	0	0	0	1	0	0	1	0	0	1	0
Peridinium,	0	pr.	0	0	0	0	0	2	pr.	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	0	pr.	pr.	pr.	0
Miscellaneous. Zoöglœa,	288	180	3,740	0	118	16	0	208	302	480	236	52
TOTAL,	308	233	3,750	3	201	121	5	389	368	504	396	83

Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of: Collection.	Date of: Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6928	Jan. 20	Jan. 21	V. slight.	V. slight.	0.30	3.85	1.00	.0036	.0152	.0138	.0014	.14	.0300	.0002	1.1
7031	Feb. 17	Feb. 18	V. slight.	V. slight.	0.30	3.35	1.25	.0022	.0110	.0094	.0016	.12	.0260	.0002	1.3
7132	Mar. 17	Mar. 18	Slight, milky.	Slight.	0.30	3.05	1.10	.0010	.0084	.0066	.0018	.11	.0230	.0001	1.1
7239	Apr. 21	Apr. 22	V. slight.	Slight.	0.20	3.05	0.80	.0000	.0050	.0036	.0014	.14	.0200	.0000	1.1
7333	May 19	May 20	Slight.	Slight.	0.20	3.10	1.20	.0016	.0118	.0088	.0030	.15	.0200	.0000	1.1
7464	June 17	June 18	Slight.	Slight.	0.35	4.20	1.80	.0022	.0168	.0124	.0044	.12	.0090	.0001	1.3
7581	July 21	July 22	Slight.	Slight.	0.30	3.60	0.85	.0054	.0160	.0140	.0020	.18	.0180	.0001	1.1
7835	Aug. 19	Aug. 20	V. slight.	V. slight.	0.10	4.15	1.75	.0052	.0126	.0110	.0016	.18	.0150	.0003	1.4
7938	Sept. 15	Sept. 16	None.	V. slight.	0.15	4.20	1.60	.0052	.0174	.0138	.0036	.20	.0090	.0002	0.6
8164	Oct. 22	Oct. 23	V. slight.	Slight.	0.20	3.75	0.80	.0038	.0154	.0110	.0044	.25	.0130	.0005	1.6
8259	Nov. 11	Nov. 12	Slight.	Slight.	0.11	4.45	1.15	.0064	.0174	.0144	.0030	.33	.0200	.0002	1.6
8343	Dec. 16	Dec. 17	Slight.	Slight.	0.40	4.25	1.40	.0016	.0108	.0080	.0028	.22	.0180	.0004	1.4
Av.	....	....	....	....	0.24	3.75	1.22	.0032	.0132	.0106	.0026	.18	.0184	.0002	1.2

Odor, generally faintly musty, occasionally vegetable, frequently none.——The samples were collected from a faucet in the gate-house and represent water flowing out of the reservoir.

LAWRENCE.

Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	22	20	20	23	21	18	22	20	17	23	13	18
Number of sample,	6928	7031	7132	7239	7333	7464	7581	7835	7938	8164	8259	8343
PLANTS.												
Diatomaceæ,	7	7	7	18	11	2	30	2	7	20	39	25
Asterionella,	0	0	3	6	0	0	0	0	0	7	7	18
Fragilaria,	0	0	0	0	0	0	0	0	0	12	0	0
Melosira,	7	6	3	0	0	0	1	0	2	1	2	0
Synedra,	0	1	1	11	10	pr.	25	pr.	3	0	30	7
Tabellaria,	0	0	0	1	1	2	4	2	2	pr.	0	pr.
Cyanophyceæ. Chroöcoccus,	0	0	0	0	0	0	53	0	0	8	0	0
Algæ,	0	0	0	0	0	3	107	54	15	115	2	3
Botrycoccus,	0	0	0	0	0	pr.	0	5	2	0	0	0
Chlorococcus,	0	0	0	0	0	3	100	49	0	115	1	3
Eudorina,	0	0	0	0	0	0	0	0	7	0	0	0
Raphidium,	0	0	0	0	0	0	7	0	6	0	1	0
Fungi. Crenothrix,	3	2	0	6	1	3	6	0	1	0	6	5
ANIMALS.												
Infusoria,	0	pr.	0	0	0	2	pr.	0	1	0	pr.	0
Dinobryon,	0	pr.	0	0	0	2	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	pr.	0	1	0	pr.	0
Crustacea. Cyclops,	0	0	0	0	0	pr.	pr.	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	76	66	114	39	154	2	238	13	128	196	134	52
TOTAL,	86	75	121	63	166	12	434	69	154	339	181	85

Volume of Water Flowing in the Merrimack River on the Dates when Samples of Water were collected for Analysis.

DATE.	VOLUME FLOWING IN THE MERRIMACK RIVER IN CUBIC FEET PER SECOND.	
	Rate of Flow during Eleven Hours of the Day.	Rate of Flow during Twenty-four Hours of the Day.
1891.		
Jan. 20,	15,820	14,960
Feb. 17,	11,180	10,300
Mar. 17,	29,050	28,400
Apr. 21,	31,900	31,260
May 19,	11,600	10,700
June 17,	3,510	2,600
July 21,	5,420	4,590
Aug. 19,	3,530	2,610
Sept. 15,	4,090	3,170
Oct. 22,	3,260	2,310
Nov. 11,	3,080	2,100
Dec. 16,	3,550	2,640

LEICESTER.

WATER SUPPLY OF LEICESTER.

Description of Works. — The works are owned by the Leicester Water-Supply District, which includes the central village of Leicester only. Water was introduced in 1891. The sources of supply are eight wells located in the valley of Kettle Brook in Paxton. One well is 30 feet in diameter and 12 feet deep. The other seven are from 6 to 7 feet in diameter and 8 to 12 feet deep. All the wells are lined with stone laid in cement, and none of them are covered, but all will probably be covered the coming summer. Water flows by gravity to the village and to an open iron tank 30 feet in diameter and 40 feet in height, the top of which is on the same level with the ground about the wells. Distributing mains are of cast iron. Service pipes are of wrought iron lined with cement.

WATER SUPPLY OF LENOX. — LENOX WATER COMPANY.

The capacity of these works has recently been increased by the construction of a second storage reservoir, holding 12,500,000 gallons, in the valley of a tributary of Williams River. The old reservoir on this same tributary has a capacity of 500,000 gallons. Water from both of these reservoirs is pumped over the ridge into the small reservoir at the head of Yoken River, and flows thence by gravity to a new distributing reservoir, having a capacity of 1,500,000 gallons. The new distributing reservoir is situated at a higher level than the old one, thereby increasing the pressure in the town.

WATER SUPPLY OF LEOMINSTER.

In 1891 a new and higher dam was built at the Morse Reservoir, increasing its capacity to 40,000,000 gallons. The bottom is of gravel and sand, the loam and vegetable matter having been removed before the reservoir was filled. About one-fourth of the area of the reservoir is less than five feet in depth, and the maximum depth is 23 feet.

LEOMINSTER.

Chemical Examination of Water from Haynes Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6922	Jan. 19	Jan. 21	Slight.	Slight, earthy.	0.30	2.60	1.20	.0012	.0240	.0196	.0044	.12	.0080	.0001	0.8
7027	Feb. 16	Feb. 17	V. slight.	V. slight.	0.15	2.40	0.95	.0002	.0068	.0042	.0026	.09	.0090	.0001	0.3
7124	Mar. 16	Mar. 17	V. slight.	V. slight.	0.03	1.10	0.25	.0046	.0046	.0034	.0012	.10	.0200	.0000	0.2
7234	Apr. 20	Apr. 21	Distinct.	Cons.	0.15	1.75	0.80	.0000	.0190	.0092	.0098	.09	.0150	.0000	0.0
7326	May 17	May 19	Distinct.	Heavy, green.	0.15	1.95	1.25	.0000	.0414	.0202	.0212	.08	.0030	.0000	0.0
7450	June 15	June 16	Decided.	Heavy.	0.30	2.65	1.20	.0002	.0534	.0290	.0244	.10	.0070	.0001	0.3
7575	July 20	July 21	Decided.	Cons., green.	0.20	3.80	2.00	.0000	.0732	.0364	.0368	.10	.0150	.0000	0.0
7832	Aug. 19	Aug. 20	Decided.	Heavy, green.	0.20	2.60	1.60	.0000	.0726	.0252	.0474	.10	.0050	.0002	0.0
7937	Sept. 15	Sept. 16	Distinct.	Cons., green.	0.20	3.60	2.35	.0000	.0590	.0298	.0292	.12	.0100	.0001	0.2
8061	Oct. 13	Oct. 14	Decided.	Heavy, green.	0.40	3.45	2.15	.0000	.0750	.0342	.0408	.11	.0000	.0000	0.0
8256	Nov. 11	Nov. 11	Decided.	Cons., green.	0.46	4.50	2.50	.0000	.0772	.0374	.0398	.11	.0150	.0000	0.0
8325	Dec. 14	Dec. 15	Decided.	Heavy, green.	0.40	3.20	1.50	.0000	.0720	.0288	.0432	.13	.0100	.0003	0.2
Av.	....	....	....	....	0.24	2.80	1.48	.0005	.0482	.0231	.0251	.10	.0097	.0001	0.2

Odor, generally none; frequently vegetable and unpleasant; on heating, generally vegetable, frequently unpleasant. —— The samples were collected from the reservoir.

Microscopical Examination.

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	22	18	18	22	20	18	21	20	16	14	13	15
Number of sample, ...	6922	7027	7124	7234	7326	7450	7575	7832	7937	8061	8256	8325
PLANTS.												
Diatomaceæ, ...	**12**	**4**	**0**	**295**	**2,372**	**89**	**244**	**77**	**570**	**3,272**	**1,333**	**785**
Asterionella, ...	3	4	0	41	140	0	0	7	12	304	0	148
Diatoma, ...	0	0	0	0	0	0	0	0	6	0	0	17
Melosira, ...	0	0	0	104	828	0	0	35	400	104	800	84
Synedra, ...	pr.	0	0	0	108	0	0	5	0	0	0	56
Tabellaria, ...	9	0	0	150	1,296	89	244	30	152	2,864	533	480
Cyanophyceæ, ...	**1**	**0**	**0**	**8**	**113**	**511**	**306**	**341**	**834**	**1,174**	**216**	**66**
Anabæna, ...	0	0	0	0	0	476	0	17	56	16	0	0
Anabæna spores, ...	0	0	0	0	0	35	0	0	0	0	0	0
Chroöcoccus, ...	0	0	0	8	75	0	137	0	276	704	0	0
Clathrocystis, ...	1	0	0	pr	36	0	162	324	496	296	183	64
Cœlosphærium, ...	0	0	0	0	0	0	0	0	0	0	33	0
Microcystis, ...	0	0	0	0	2	0	7	0	6	120	0	2
Nostoc, ...	0	0	0	0	0	0	0	0	0	38	0	0

LEOMINSTER.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	**12**	**0**	**0**	**35**	**1,310**	**16**	**42**	**12**	**680**	**5,626**	**25,132**	**5,465**
Arthrodesmus,	0	0	0	0	5	0	1	0	1	0	0	0
Chlorococcus,	4	0	0	0	304	0	7	4	360	0	0	0
Ophiocytium,	0	0	0	0	9	0	0	0	0	0	0	0
Nephrocytium,	0	0	0	0	0	0	0	0	19	0	0	0
Pediastrum,	0	0	0	1	20	1	7	5	15	4	0	1
Raphidium,	0	0	0	0	76	2	2	0	200	8	66	0
Scenedesmus,	3	0	0	34	880	0	7	2	56	14	0	68
Sorastrum,	0	0	0	0	5	0	1	0	4	0	0	0
Staurastrum,	5	0	0	0	5	13	17	1	5	8	0	8
Tetraspora,	0	0	0	0	0	0	0	0	0	5,592	25,066	5,388
Xanthidium,	0	0	0	0	6	0	0	0	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**3**
ANIMALS.												
Infusoria,	**180**	**pr.**	**pr.**	**11**	**0**	**1**	**0**	**0**	**19**	**12**	**0**	**1**
Peridinium,	180	pr.	pr.	11	0	0	0	0	2	8	0	0
Trachelomonas,	0	0	0	0	0	1	0	0	17	4	0	1
Vermes,	**1**	**0**	**0**	**0**	**5**	**0**	**0**	**1**	**0**	**4**	**0**	**0**
Anurea,	1	0	0	0	2	0	0	1	0	2	0	0
Conochilus,	0	0	0	0	0	0	0	0	0	2	0	0
Polyarthra,	0	0	0	0	3	0	0	0	0	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**0**	**0**	**0**	**0**	**0**
Bosmina,	0	0	0	0	0	pr.	pr.	0	0	0	0	0
Cyclops,	0	0	0	0	0	0	pr.	0	0	0	0	0
Miscellaneous. Zoöglœa,	**5**	**0**	**0**	**152**	**768**	**0**	**73**	**0**	**320**	**472**	**0**	**68**
TOTAL,	211	4	pr.	505	4,568	617	665	431	2,404	10,562	26,681	6,388

WATER SUPPLY OF LEXINGTON. — LEXINGTON WATER COMPANY.

Three new wells have been added to the works, making five in all. Two of these are in line with the original wells and farther from the pumping station. The one farthest from the pumping station is 12 feet in diameter and 11 feet in depth, the other one 10 feet in diameter and 11 feet in depth. Both are covered to exclude the light. The third well is located near the original wells and the pumping station, and is a tubular well, 8 inches in diameter and 190 feet deep. This well is operated by an independent deep well pump, the water being pumped into one of the large wells. Still

LEXINGTON.

another well was begun but was abandoned before being completed. A pipe has been laid by which water can be drawn into the wells from one of the channels of Vine Brook when necessary. The brook dries up, however, in very dry weather. The material in the vicinity of the new wells is generally peat, underlaid with hard pan and rock.

Chemical Examination of Water from the Works of the Lexington Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7148	Mar. 26	Mar. 28	V. slight.	Slight.	0.50	3.75	0.75	.0008	.0086	-	-	.24	.0120	.0000	2.0
7149	Mar. 26	Mar. 28	None.	Cons, earthy.	0.00	3.60	-	.0006	.0030	.0008	.0022	.24	.0150	.0001	1.6
7150	Mar. 26	Mar. 28	V. slight.	Cons.	0.70	5.25	1.85	.0050	.0168	.0140	.0028	.35	.0650	.0000	2.1
7151	Mar. 26	Mar. 28	None.	None.	0.00	9.90	-	.0000	.0000	-	-	.32	.0050	.0000	7.0

Odor of Nos. 7148 and 7150, vegetable; of the others, none.——No. 7148 was collected from the well farthest from the pumping station. No. 7149 was collected from Seaverns Spring, which discharges into one of the channels of Vine Brook above the wells. No. 7150 was collected from Vine Brook, opposite the wells. No. 7151 was collected from the deep tubular well.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. March.	1891. March.	1891. March.	1891. March.
Day of examination,	28	28	28	28
Number of sample,	7148	7149	7150	7151
PLANTS.				
Diatomaceæ,	**29**	**1**	**18**	**0**
Meridion,	29	pr.	14	0
Navicula,	0	0	3	0
Synedra,	0	1	1	0
ANIMALS.				
Infusoria,	**0**	**0**	**2**	**0**
Peridinium,	0	0	1	0
Synura,	0	0	1	0
Miscellaneous. Zoöglœa,	**13**	**18**	**116**	**0**
TOTAL,	42	19	136	0

Water Supply of Lowell.

Chemical Examination of Water from the Merrimack River above Lowell, opposite the Inlet to the Lowell Water Works.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6921	Jan. 19	Jan. 20	V. slight.	Slight.	0.40	3.45	1.20	.0018	.0142	.0122	.0020	.08	.0180	.0001	1.0
7028	Feb. 16	Feb. 17	V. slight.	V. slight.	0.30	3.30	1.05	.0000	.0066	.0054	.0012	.10	.0190	.0002	1.3
7123	Mar. 16	Mar. 17	Slight, clayey.	Cons.	0.25	2.65	1.00	.0000	.0138	.0108	.0030	.06	.0100	.0001	0.9
7238	Apr. 20	Apr. 21	Decided.	Heavy, earthy.	0.23	2.30	0.75	.0002	.0084	.0066	.0018	.06	.0120	.0001	0.8
7330	May 19	May 20	Distinct.	Heavy.	0.30	3.10	1.05	.0004	.0142	.0106	.0036	.10	.0070	.0001	1.1
7451	June 15	June 16	V. slight.	Slight.	0.30	3.60	1.55	.0016	.0144	.0106	.0038	.16	.0090	.0002	–
7576	July 20	July 21	Slight.	Slight.	0.50	3.40	1.80	.0020	.0142	.0100	.0042	.14	.0070	.0001	1.1
7833	Aug. 19	Aug. 20	Slight.	Slight.	0.10	3.15	1.60	.0002	.0140	.0118	.0022	.12	.0030	.0003	1.1
7930	Sept. 14	Sept. 15	V. slight.	V. slight.	0.20	3.65	1.15	.0012	.0120	.0080	.0040	.15	.0100	.0000	1.6
8158	Oct. 21	Oct. 22	Slight.	Slight.	0.20	3.75	1.25	.0048	.0128	.0100	.0028	.22	.0090	.0002	1.6
8253	Nov. 10	Nov. 11	Slight.	Slight.	0.30	4.85	1.50	.0078	.0208	.0164	.0044	.24	.0100	.0002	1.4
8334	Dec. 15	Dec. 16	Slight.	V. slight.	0.40	4.00	0.90	.0004	.0096	.0080	.0016	.17	.0500	.0001	1.1
Av.	....	....	....	....	0.29	3.43	1.23	.0017	.0129	.0100	.0029	.13	.0137	.0001	1.2

Odor, generally faintly vegetable or musty, frequently none.——The samples were collected from the river, opposite the inlet to the Lowell Water Works, one foot beneath the surface.

* For additional analyses of water from the Merrimack River at Lowell, see *Merrimack River* in the chapter headed "Rivers."

LOWELL.

Microscopical Examination of Water from the Merrimack River above Lowell, opposite the Inlet to the Lowell Water Works.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	22	18	18	22	21	18	22	20	16	23	12	17
Number of sample,	6921	7028	7123	7233	7330	7451	7576	7833	7930	8158	8253	8334
PLANTS.												
Diatomaceæ,	**19**	**4**	**5**	**0**	**101**	**90**	**132**	**121**	**65**	**28**	**15**	**27**
Asterionella,	0	0	0	0	4	2	0	1	6	2	pr.	7
Diatoma,	2	1	0	0	0	2	0	0	1	0	1	0
Fragilaria,	0	0	0	0	0	0	32	0	2	0	0	1
Melosira,	14	0	2	0	42	2	4	21	0	2	0	5
Navicula,	pr.	0	2	0	4	0	4	3	6	3	pr.	pr.
Nitzschia,	1	0	0	0	12	0	0	0	0	0	0	0
Synedra,	2	3	1	0	36	72	82	84	42	18	14	11
Tabellaria,	0	0	0	0	3	12	10	12	8	3	0	3
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**72**	**47**	**24**	**0**	**2**	**0**
Chroöcoccus,	0	0	0	0	0	0	71	44	23	0	0	0
Microcystis,	0	0	0	0	0	0	1	3	1	0	2	0
Algæ,	**0**	**0**	**0**	**0**	**0**	**17**	**128**	**44**	**11**	**6**	**0**	**0**
Botryococcus,	0	0	0	0	0	0	0	7	0	0	0	0
Chlorococcus,	0	0	0	0	0	17	116	33	10	4	0	0
Merismopedia,	0	0	0	0	0	0	10	0	0	0	0	0
Raphidium,	0	0	0	0	0	0	2	4	1	2	0	0
Fungi. Crenothrix,	**1**	**0**	**0**	**0**	**3**	**3**	**12**	**1**	**34**	**42**	**22**	**7**
ANIMALS.												
Infusoria,	**pr.**	**0**	**pr.**	**0**	**2**	**3**	**7**	**32**	**1**	**17**	**0**	**3**
Dinobryon,	pr.	0	0	0	0	0	2	30	0	14	0	2
Dinobryon cases,	0	0	0	0	0	0	0	0	0	3	0	0
Monas,	0	0	pr.	0	0	0	1	0	1	0	0	1
Paramæcium,	0	0	0	0	2	0	0	0	0	0	0	0
Peridinium,	0	0	0	0	0	0	2	2	pr.	0	0	0
Trachelomonas,	0	0	0	0	0	3	2	0	0	0	0	0
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**108**	**244**	**398**	**0**	**242**	**34**	**440**	**3**	**240**	**100**	**146**	**62**
TOTAL,	128	248	403	0	348	147	791	248	375	193	185	99

LOWELL.

Chemical Examination of Water from Faucets in Lowell, supplied from the Lowell Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7063	Feb. 24	Feb. 25	V. slight.	V. slight.	0.33	3.60	1.35	.0024	.0112	.0092	.0020	.10	.0250	.0001	1.27
7125	Mar. 16	Mar. 17	V. slight.	V. slight.	0.25	3.30	0.80	.0030	.0094	.0080	.0014	.13	.0250	.0000	1.27
7127	Mar. 16	Mar. 17	V. slight.	V. slight.	0.20	3.40	0.95	.0004	.0068	.0056	.0012	.12	.0250	.0000	1.27

Odor of No. 7063, very faintly musty; of the others, none.——No. 7063 was collected from a faucet on Middlesex Street; No. 7125 from a faucet supplied from the high service at Tenth and Christian streets; No. 7127 from a faucet supplied from the high service at 285 Rogers Street.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. February.	1891. March.	1891. March.
Day of examination,	26	18	18
Number of sample,	7063	7125	7127
PLANTS.			
Diatomaceæ. Melosira,	6	1	0
Algæ. Zoöspores,	0	3	0
ANIMALS.			
Rhizopoda. Actinophrys,	0	1	0
Miscellaneous. Zoöglœa,	100	122	0
TOTAL,	106	127	0

WATER SUPPLY OF LUDLOW.

(See *Springfield.*)

LYNN.

WATER SUPPLY OF LYNN.

Chemical Examination of Water from Breed's Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6894	Jan. 14	Jan. 15	Slight.	V. slight.	0.50	4.30	1.50	.0016	.0208	.0186	.0022	.46	.0100	.0001	1.3
7014	Feb. 12	Feb. 13	V. slight.	V. slight.	0.30	3.00	0.85	.0034	.0106	.0094	.0012	.34	.0060	.0001	0.8
7110	Mar. 10	Mar. 11	V. slight.	V. slight.	0.40	2.95	1.45	.0000	.0064	.0054	.0010	.30	.0200	.0000	0.5
7219	Apr. 15	Apr. 16	V. slight.	V. slight.	0.30	3.25	1.15	.0002	.0106	.0084	.0022	.39	.0150	.0001	0.8
7316	May 13	May 14	Slight.	Slight.	0.30	3.45	1.40	.0004	.0150	.0118	.0032	.41	.0020	.0000	0.8
7433	June 10	June 12	Slight.	Slight.	0.30	3.65	1.55	.0026	.0160	.0146	.0014	.37	.0050	.0000	0.8
7791	Aug. 12	Aug. 13	Slight.	Slight.	0.20	3.20	1.85	.0006	.0152	.0128	.0024	.40	.0020	.0000	0.6
7827	Aug. 19	Aug. 20	Slight.	Slight.	0.15	-	-	.0000	.0136	.0122	.0014	.40	.0000	.0001	0.8
7892	Sept. 2	Sept. 3	Slight.	Slight.	0.30	-	-	.0004	.0182	.0164	.0018	.42	.0100	.0001	0.6
7913	Sept. 10	Sept. 11	Slight.	V. slight.	0.20	-	-	.0000	.0210	.0174	.0036	-	.0050	.0000	-
7953	Sept. 17	Sept. 18	Slight.	Slight.	0.30	3.70	1.60	.0000	.0226	.0164	.0062	.42	.0000	.0000	0.8
7972	Sept. 23	Sept. 24	Distinct.	Slight.	0.15	-	-	.0000	.0266	.0204	.0062	-	.0050	.0001	-
7980	Sept. 30	Sept. 30	Slight.	Slight, green.	0.30	3.30	2.15	.0002	.0232	.0196	.0036	.43	.0050	.0001	0.6
8029	Oct. 7	Oct. 8	V. slight.	Slight.	0.40	-	-	.0012	.0288	.0246	.0042	-	.0050	.0000	-
8106	Oct. 14	Oct. 15	V. slight.	Slight.	0.45	-	-	.0016	.0226	.0186	.0040	-	.0050	.0001	-
8154	Oct. 21	Oct. 22	Slight.	Slight.	0.45	-	-	.0000	.0152	.0120	.0032	-	.0090	.0001	-
8169	Oct. 28	Oct. 29	Slight.	Slight.	0.45	2.75	1.20	.0020	.0200	.0174	.0026	.41	.0100	.0000	0.6
8212	Nov. 4	Nov. 5	V. slight.	Slight.	0.65	3.50	1.10	.0004	.0202	.0168	.0034	.48	.0100	.0002	0.6
8317	Dec. 9	Dec. 10	Slight.	Slight.	0.60	3.35	1.60	.0000	.0140	.0106	.0034	.45	.0070	.0000	0.8
Av.	....	....	....	....	0.35	3.35	1.37	.0009	.0156	.0131	.0025	.40	.0080	.0001	0.8

Odor, faintly vegetable or none until September 15, excepting Nos. 7433 and 7791, which were mouldy; after this date distinctly vegetable and frequently grassy, often becoming very strong on heating.——The samples were collected from the pond near the gate-house, about one foot beneath the surface.

Microscopical Examination of Water from Breed's Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1891.									
	Jan.	Feb.	Mar.	Apr.	May.	June.	Aug.	Aug.	Sept.	Sept.
Day of examination,	15	14	12	16	14	12	13	20	3	11
Number of sample,	6894	7014	7110	7219	7316	7433	7791	7827	7892	7913
PLANTS.										
Diatomaceæ,	3	0	0	35	21	3	24	182	1,390	1,874
Asterionella,	pr.	0	0	9	20	3	2	5	48	328
Cyclotella,	0	0	0	22	0	0	0	0	0	0
Diatoma,	0	0	0	0	0	0	pr.	0	1,292	1,472
Melosira,	3	0	0	0	0	0	1	0	15	6
Navicula,	0	0	0	0	1	0	pr.	1	0	1
Synedra,	0	0	0	4	pr.	0	0	pr.	0	0
Tabellaria,	0	0	0	0	0	0	21	176	35	67
Cyanophyceæ,	0	0	0	0	0	0	33	39	4	21
Anabæna,	0	0	0	0	0	0	28	39	0	0
Anabæna spores,	0	0	0	0	0	0	5	0	0	0
Nostoc,	0	0	0	0	0	0	0	0	4	21
Algæ,	0	0	0	34	0	10	0	101	8	8
Chlorococcus,	0	0	0	32	0	2	0	90	8	8
Dictyosphærium,	0	0	0	0	0	0	0	pr.	0	0
Raphidium,	0	0	0	0	0	0	0	11	0	0
Zoöspores,	0	0	0	2	0	8	0	0	0	0
ANIMALS.										
Rhizopoda. Actinophrys,	0	0	pr.	pr.	19	7	0	pr.	1	0
Infusoria,	1	7	3	5	45	0	89	24	10	178
Dinobryon,	0	7	2	2	45	0	0	18	0	0
Dinobryon cases,	0	0	0	0	0	0	85	0	0	0
Euglena,	0	0	0	0	0	0	0	0	0	0
Glenodinium,	0	0	0	2	0	0	1	2	3	0
Peridinium,	1	0	1	1	0	0	3	4	4	156
Trachelomonas,	0	0	0	0	0	0	pr.	0	3	21
Vorticella,	0	0	0	0	0	0	0	0	0	1
Vermes. Rotatorian ova,	0	4	0	0	0	0	pr.	0	0	0
Crustacea,	0	pr.	0	0	0	pr.	0	pr.	0	pr.
Cyclops,	0	pr.	0	0	0	pr.	0	pr.	0	pr.
Daphnia,	0	0	0	0	0	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	pr.	0	94	25	1	0	82	38	400	184
TOTAL,	4	11	97	99	86	20	228	384	1,813	2,265

LYNN.

Microscopical Examination of Water from Breed's Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1891.								
	Sept.	Sept.	Oct.	Oct.	Oct.	Oct.	Oct.	Nov.	Dec.
Day of examination,	18	24	1	8	15	22	30	5	10
Number of sample,	7953	7972	7980	8029	8106	8154	8169	8212	8317
PLANTS.									
Diatomaceæ,	**1,738**	**1,534**	**672**	**320**	**69**	**140**	**57**	**58**	**278**
Asterionella,	308	528	464	198	9	4	4	19	80
Cyclotella,	0	0	0	0	0	0	0	0	3
Diatoma,	1,332	828	0	0	0	pr.	0	0	1
Melosira,	0	0	7	4	7	0	0	0	0
Navicula,	2	2	1	0	3	0	0	1	pr.
Synedra,	0	0	0	0	1	0	1	1	58
Tabellaria,	96	176	200	118	49	136	52	37	136
Cyanophyceæ,	**92**	**148**	**0**	**12**	**3**	**0**	**1**	**22**	**0**
Anabæna,	92	148	0	8	3	0	1	22	0
Anabæna spores,	0	0	0	4	0	0	0	0	0
Nostoc,	0	0	0	0	0	0	0	0	0
Algæ,	**0**	**8**	**21**	**0**	**pr.**	**55**	**48**	**0**	**4**
Chlorococcus,	0	0	21	0	0	pr.	0	0	4
Dictyosphærium,	0	0	0	0	0	55	48	0	0
Raphidium,	0	0	0	0	0	0	0	0	0
Zoöspores,	0	8	0	0	pr.	pr.	0	0	0
ANIMALS.									
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**43**	**96**	**20**	**41**	**19**	**128**	**89**	**144**	**52**
Dinobryon,	0	0	2	0	18	48	82	109	2
Dinobryon cases,	0	0	0	35	0	80	4	29	50
Euglena,	0	0	5	0	0	0	0	0	0
Glenodinium,	3	0	0	0	0	0	0	0	0
Peridinium,	33	68	6	3	1	0	1	pr.	0
Trachelomonas,	7	28	7	3	pr.	pr.	2	0	0
Vorticella,	0	0	0	0	0	0	0	6	0
Vermes. Rotatorian ova,	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**
Crustacea,	**pr.**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cyclops,	pr.	pr.	0	0	0	0	0	0	0
Daphnia,	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**84**	**284**	**228**	**60**	**154**	**88**	**56**	**19**	**64**
TOTAL,	1,958	2,071	941	433	245	411	251	243	398

LYNN.

Chemical Examination of Water from a Spring and a Brook which discharge into Breed's Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7109	Mar. 10	Mar. 11	None.	None.	0.05	2.55	0.95	.0000	.0028	.0022	.0006	.48	.0200	.0000	0.6
7220	Apr. 15	Apr. 16	None.	Slight.	0.00	2.75	0.40	.0000	.0014	.0010	.0004	.42	.0200	.0000	0.9

Odor of No. 7109, none; of No. 7220, vegetable. —— No. 7109 was collected from a spring on the border of Breed's Pond. No. 7220 was collected from a brook which flows into Breed's Pond.

Microscopical Examination.

No. 7109. Diatomaceæ, *Diatoma*, 1; *Melosira*, 2; *Meridion*, 1; *Navicula*, pr.; *Nitzschia*, 1; *Synedra*, pr. Infusoria, *Peridinium*, pr. Miscellaneous, *Zoöglœa*, 9. Total, 14.

No. 7220. Diatomaceæ, *Diatoma*, 246; *Fragilaria*, 23; *Melosira*, pr.; *Navicula*, pr.; *Synedra*, 4. Algæ, *Conferva*, pr.; *Hyalotheca*, pr. Vermes, *Anurea*, pr. Miscellaneous, *Zoöglœa*, 16. Total, 289.

Chemical Examination of Water from Birch Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6893	Jan. 14	Jan. 15	Distinct.	V. slight.	0.55	3.65	1.35	.0014	.0244	.0194	.0050	.48	.0150	.0001	1.1
7013	Feb. 12	Feb. 13	Distinct.	V. slight.	0.20	2.95	0.85	.0000	.0250	.0142	.0108	.32	.0070	.0002	0.8
7113	Mar. 10	Mar. 11	Slight.	V. slight.	0.00	2.25	0.70	.0006	.0068	.0052	.0016	.35	.0120	.0000	0.5
7222	Apr. 15	Apr. 16	Slight.	Slight.	0.20	2.85	0.90	.0000	.0148	.0102	.0046	.37	.0060	.0001	0.6
7315	May 13	May 14	Slight.	Slight.	0.25	2.90	0.95	.0000	.0184	.0152	.0032	.41	.0020	.0000	0.8
7432	June 10	June 12	Slight.	Slight.	0.30	3.20	1.40	.0030	.0260	.0218	.0042	.36	.0050	.0001	0.6
7792	Aug. 12	Aug. 13	Distinct.	Slight.	0.60	3.70	1.35	.0000	.0226	.0184	.0042	.38	.0030	.0000	0.6
7828	Aug. 19	Aug. 20	Distinct.	Slight.	0.55	-	-	.0000	.0226	.0166	.0060	.44	.0050	.0001	0.6
7862	Aug. 26	Aug. 27	Distinct.	Slight.	0.60	-	-	.0000	.0266	.0246	.0020	-	.0070	.0002	-
7891	Sept. 2	Sept. 3	Distinct.	Slight.	0.60	-	-	.0010	.0302	.0220	.0082	.42	.0090	.0001	0.6
7914	Sept. 10	Sept. 11	Distinct.	V. slight.	0.50	-	-	.0000	.0340	.0220	.0120	-	.0070	.0001	-
7955	Sept. 17	Sept. 18	Distinct.	Slight.	0.50	3.40	1.55	.0000	.0352	.0202	.0150	.44	.0000	.0000	0.6
7973	Sept. 23	Sept. 24	Distinct.	Slight.	0.50	-	-	.0002	.0328	.0234	.0094	-	.0050	.0001	-
7981	Sept. 30	Sept. 30	Slight.	Cons.	0.60	3.85	2.25	.0002	.0262	.0228	.0034	.43	.0050	.0000	0.6
8026	Oct. 7	Oct. 8	Distinct.	Slight.	0.55	-	-	.0004	.0338	.0282	.0056	-	.0050	.0000	-
8107	Oct. 14	Oct. 15	Slight.	Slight.	0.55	-	-	.0000	.0308	.0242	.0066	-	.0020	.0001	-
8153	Oct. 21	Oct. 22	Decided.	Slight.	0.50	-	-	.0000	.0344	.0258	.0086	-	.0000	.0001	-
8171	Oct. 28	Oct. 29	Distinct.	Cons.	0.50	3.25	1.30	.0004	.0236	.0180	.0056	.44	.0100	.0000	1.3
8214	Nov. 4	Nov. 5	Slight.	Cons.	0.70	3.50	1.15	.0000	.0240	.0190	.0050	.47	.0050	.0000	0.5
8318	Dec. 9	Dec. 10	Decided.	Cons.	0.80	4.00	2.50	.0000	.0398	.0308	.0090	.40	.0050	.0001	0.8
Av.	....	....	....	....	0.42	3.26	1.30	.0005	.0241	.0183	.0058	.40	.0065	.0001	0.7

Odor, until September, faintly vegetable or none, decidedly mouldy in June; during the remainder of the year, generally decidedly vegetable and grassy, becoming disagreeable on heating. —— The samples were collected from the pond near the gate-house, about one foot beneath the surface.

LYNN.

Microscopical Examination of Water from Birch Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1891.									
	Jan.	Feb.	Mar.	Apr.	May.	June.	Aug.	Aug.	Aug.	Sept.
Day of examination,	15	14	12	17	14	12	13	20	27	8
Number of sample,	6893	7013	7113	7222	7315	7432	7792	7828	7862	7891
PLANTS.										
Diatomaceæ,	0	pr.	2	189	152	13	580	124	103	189
Asterionella,	0	0	0	34	56	4	12	6	9	27
Cyclotella,	0	0	0	114	0	0	0	0	0	0
Diatoma,	0	0	0	0	0	1	0	0	0	32
Melosira,	0	0	2	0	0	0	0	0	0	6
Synedra,	0	pr.	0	31	10	2	0	0	8	4
Tabellaria,	0	0	0	10	86	6	568	118	86	120
Cyanophyceæ,	0	0	0	1	0	14	55	186	154	247
Anabæna,	0	0	0	0	0	0	pr.	5	33	68
Anabæna spores,	0	0	0	0	0	0	0	0	0	0
Aphanocapsa,	0	0	0	0	0	0	13	28	23	62
Chroöcoccus,	0	0	0	1	0	0	0	0	0	2
Clathrocystis,	0	0	0	0	0	1	17	73	56	108
Cœlosphærium,	0	0	0	0	0	0	25	1	0	5
Microcystis,	0	0	0	0	0	0	pr.	79	42	2
Nostoc,	0	0	0	0	0	13	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	0	0
Algæ,	34	0	1	18	18	219	25	10	24	13
Chlorococcus,	0	0	0	0	10	218	6	0	11	0
Dictyosphærium,	0	0	0	0	0	0	2	1	0	0
Pediastrum,	0	0	0	0	0	0	1	pr.	1	1
Protococcus,	34	0	1	0	0	0	0	0	0	0
Raphidium,	0	0	0	8	7	0	2	3	2	6
Scenedesmus,	0	0	0	0	0	pr.	0	0	0	0
Staurastrum,	0	0	0	0	1	1	14	6	10	6
Staurogenia,	0	0	0	0	0	0	0	0	0	0
Zoöspores,	0	0	0	10	0	0	0	0	0	0
ANIMALS.										
Rhizopoda. Actinophrys,	4	80	0	0	3	4	0	1	0	0
Infusoria,	4	14	3	185	36	6	33	2	5	9
Dinobryon,	2	1	0	21	30	6	28	0	0	0
Dinobryon cases,	0	0	0	0	0	0	1	0	0	0
Glenodinium,	0	5	0	4	0	0	0	0	0	0
Monas,	1	0	pr.	2	0	0	0	0	0	2
Peridinium,	1	8	3	158	1	0	4	2	2	0
Peridinium cases,	0	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	pr.	pr.	pr.	1	7
Vorticella,	0	0	0	0	5	0	0	0	2	0
Vermes. Anuræa,	1	0	0	1	0	0	1	0	0	0
Crustacea. Cyclops,	0	0	0	0	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	12	136	92	34	82	0	50	0	50	368
TOTAL,	55	230	98	428	291	256	744	323	336	826

LYNN.

Microscopical Examination of Water from Birch Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1891.									
	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct.	Oct.	Nov.	Dec.
Day of examination,	11	18	24	1	8	15	22	30	6	10
Number of sample,	7914	7955	7973	7981	8026	8107	8153	8171	8214	8318
PLANTS.										
Diatomaceæ,	417	427	666	599	592	562	941	5,044	1,491	2,308
Asterionella,	180	192	320	48	146	218	194	2,560	820	1,056
Cyclotella,	0	0	0	0	0	0	0	7	pr.	4
Diatoma,	112	87	62	0	0	0	2	0	0	52
Melosira,	7	0	0	3	0	0	6	0	0	0
Synedra,	2	0	0	0	0	0	29	5	3	4
Tabellaria,	116	148	284	548	446	344	710	2,472	668	1,192
Cyanophyceæ,	406	559	630	96	64	42	11	67	37	13
Anabæna,	256	140	404	9	11	12	6	1	6	0
Anabæna spores,	0	256	0	0	0	0	0	17	0	0
Aphanocapsa,	46	52	54	17	14	3	2	0	0	0
Chroöcoccus,	15	12	76	16	19	0	0	0	3	0
Clathrocystis,	72	96	68	52	12	26	1	2	0	13
Cœlosphærium,	4	0	28	2	5	1	2	3	0	0
Microcystis,	13	3	0	0	3	0	pr.	44	8	0
Nostoc,	0	0	0	0	0	0	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	25	0
Algæ,	8	33	24	74	26	142	122	99	36	15
Chlorococcus,	0	0	0	0	9	4	10	25	7	14
Dictyosphærium,	0	0	0	1	1	115	42	0	0	0
Pediastrum,	0	0	2	1	1	2	pr.	1	pr.	0
Protococcus,	0	0	0	0	0	0	0	0	pr.	0
Raphidium,	6	30	18	64	13	20	58	44	8	0
Scenedesmus,	1	2	1	4	0	pr.	7	9	2	1
Staurastrum,	1	1	1	3	2	1	pr.	3	1	0
Staurogenia,	0	0	1	1	0	0	5	17	18	0
Zoöspores,	0	0	1	0	0	0	0	0	0	0
ANIMALS.										
Rhizopoda. Actinophrys,	7	2	8	1	4	1	pr.	1	pr.	0
Infusoria,	10	9	7	68	5	12	12	66	10	38
Dinobryon,	0	0	0	57	0	7	3	3	0	12
Dinobryon cases,	0	0	0	0	1	0	0	3	9	0
Glenodinium,	0	0	0	0	0	0	0	0	0	0
Monas,	1	3	2	2	1	3	pr.	0	pr.	3
Peridinium,	3	0	0	1	0	pr.	6	40	pr.	23
Peridinium cases,	0	0	0	0	0	0	0	18	0	0
Trachelomonas,	6	6	5	8	3	2	3	2	1	0
Vorticella,	0	0	0	0	0	0	pr.	0	0	0
Vermes. Anurea,	0	0	1	0	1	0	1	1	0	0
Crustacea. Cyclops,	0	pr.	0	pr.	pr.	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	476	364	260	196	72	140	126	216	522	28
TOTAL,	1,324	1,394	1,596	1,034	764	899	1,213	5,494	2,096	2,402

LYNN.

Chemical Examination of Water from Walden Pond, Lynn.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.	
	1891.														
6891	Jan. 14	Jan. 15	Decided.	Heavy, d. green.	1.30	5.10	2.90	.0024	.4280	.1060	.3220	.38	.0000	.0000	1.1
6906	Jan. 17	Jan. 17	Distinct.	Slight.	1.30	-	-	.0008	.1020	.0460	.0560	-	.0210	.0002	-
6907	Jan. 17	Jan. 17	Slight.	Slight.	1.70	-	-	.0760	.0534	.0520	.0014	-	.0250	.0005	-
7015	Feb. 12	Feb. 13	Slight.	V. slight.	0.70	3.25	1.30	.0134	.0300	.0192	.0108	.26	.0030	.0001	0.6
7083	Feb. 27	Mar. 3	V. slight.	V. slight.	0.30	2.55	0.90	.0044	.0130	.0098	.0032	.19	.0030	.0001	0.3
7111	Mar. 10	Mar. 11	V. slight.	V. slight.	0.45	2.75	1.20	.0066	.0092	.0076	.0016	.33	.0100	.0001	0.5
7223	Apr. 15	Apr. 16	Slight.	Slight.	0.35	3.30	1.35	.0014	.0284	.0182	.0102	.31	.0250	.0000	0.6
7317	May 13	May 14	Distinct.	Slight.	0.70	3.30	1.45	.0184	.0388	.0284	.0104	.30	.0020	.0001	0.6
7430	June 10	June 12	Distinct.	Cons.	0.75	4.45	2.15	.0272	.0614	.0398	.0216	.27	.0070	.0000	1.1
7579	July 21	July 22	Distinct.	Cons.	1.30	4.75	2.75	.0028	.0652	.0416	.0236	.34	.0150	.0000	0.5
7794	Aug. 12	Aug. 13	Distinct.	Cons.	1.40	5.15	2.90	.0012	.0574	.0412	.0162	.45	.0050	.0000	0.8
7830	Aug. 19	Aug. 20	Decided.	Cons.	1.20	-	-	.0000	.0508	.0414	.0094	.39	.0050	.0002	0.8
7861	Aug. 26	Aug. 27	Distinct.	Slight.	1.80	-	-	.0144	.0666	.0522	.0144	-	.0070	.0000	-
7894	Sept. 2	Sept. 3	Slight, green.	Slight.	1.50	-	-	.0000	.0636	.0476	.0160	.36	.0090	.0000	0.8
7912	Sept. 10	Sept. 11	Distinct, green.	Cons., green.	1.60	-	-	.0000	.0732	.0476	.0256	-	.0030	.0000	-
7954	Sept. 17	Sept. 18	Distinct, green.	Slight.	1.60	5.15	2.65	.0000	.0668	.0512	.0156	.28	.0050	.0000	0.8
7975	Sept. 23	Sept. 24	Distinct.	Cons.	1.60	-	-	.0000	.0650	.0532	.0118	-	.0070	.0000	-
7979	Sept. 30	Sept. 30	Distinct.	Slight.	1.60	6.05	3.45	.0000	.0676	.0506	.0170	.40	.0100	.0001	0.9
8028	Oct. 7	Oct. 8	Decided.	Cons., green.	1.80	-	-	.0004	.1612	.0626	.0986	-	.0070	.0000	-
8109	Oct. 14	Oct. 15	Distinct, green.	Cons., green.	1.50	-	-	.0002	.1106	.0464	.0642	-	.0030	.0002	-
8156	Oct. 21	Oct. 22	Distinct.	Cons.	1.40	-	-	.0018	.0712	.0528	.0184	-	.0070	.0003	-
8168	Oct. 28	Oct. 29	Slight, green.	Slight.	1.20	5.25	3.25	.0122	.0564	.0462	.0102	.36	.0100	.0000	0.6
8215	Nov. 4	Nov. 5	Slight.	Cons.	1.40	5.25	2.25	.0096	.0516	.0460	.0056	.41	.0100	.0003	0.5
8319	Dec. 9	Dec. 10	Distinct.	Slight.	1.20	4.95	2.95	.0124	.0438	.0382	.0056	.39	.0250	.0002	0.6
Av..	....	....	....	....	1.21	4.32	2.20	.0058	.0615	.0403	.0212	.34	.0091	.0001	0.7

Odor, until September 17, generally distinctly vegetable, frequently unpleasant. After September 17, generally decidedly vegetable and grassy, occasionally unpleasant. —— The samples were collected from the pond near the gate-house, one foot beneath the surface, with the exception of No. 6907, which was collected from near the bottom, and is omitted from the average.

No. 6891 is also omitted from the average, because it probably does not fairly represent the general character of the water in the pond.

LYNN.

Microscopical Examination of Water from Walden Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Jan.	Jan.	Feb.	Mar.	Mar	Apr.	May.	June.	July.	Aug.	Aug.
Day of examination,	15	19	20	14	5	12	17	14	12	22	13	20
Number of sample,	6891	6906	6907	7015	7083	7111	7223	7317	7430	7579	7794	7830
PLANTS.												
Diatomaceæ,	0	0	0	0	0	0	33	1	0	0	0	0
Synedra,	0	0	0	0	0	0	33	1	0	0	0	0
Tabellaria,	0	0	0	0	0	0	pr.	0	0	0	0	0
Cyanophyceæ,	0	0	0	0	0	0	0	15	8	12	2	165
Anabæna,	0	0	0	0	0	0	0	0	0	11	1	80
Anabæna spores,	0	0	0	0	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	0	15	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	0	0	0	0	1	80
Cœlosphærium,	0	0	0	0	0	0	0	0	0	0	0	2
Microcystis,	0	0	0	0	0	0	0	0	0	0	0	0
Nostoc,	0	0	0	0	0	0	0	0	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	8	1	0	3
Algæ,	0	pr.	5	0	0	0	2	148	26	404	12	13
Chlorococcus,	0	0	5	0	0	0	0	0	18	3	2	9
Closterium,	0	0	0	0	0	0	2	0	0	0	0	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	0	0	0
Pandorina,	0	0	0	0	0	0	0	78	3	2	pr.	0
Pediastrum,	0	0	0	0	0	0	0	0	pr.	390	1	0
Protococcus,	0	0	0	0	0	0	0	70	0	0	0	0
Staurastrum,	0	0	0	0	0	0	0	0	5	8	3	4
Volvox,	0	pr.	0	0	0	0	0	0	0	0	2	0
Zoöspores,	0	0	0	0	0	0	pr.	0	0	1	4	0
Fungi. Crenothrix,	0	0	32	0	0	0	0	0	0	0	0	12
ANIMALS.												
Rhizopoda. Actinophrys,	5	0	0	0	0	0	0	0	0	0	0	0
Infusoria,	19,840	2,280	47	39	21	0	244	pr.	0	7	76	186
Cryptomonas,	19,840	2,280	46	38	20	0	0	0	0	0	0	0
Glenodinium,	0	0	0	0	0	0	0	0	0	0	0	5
Monas,	0	0	0	0	0	0	0	0	0	1	0	0
Peridinium,	0	pr.	0	1	1	0	244	0	0	0	7	0
Synura,	0	0	0	0	0	0	0	0	0	1	68	178
Trachelomonas,	0	0	1	0	0	0	0	pr.	0	5	1	3
Vermes. Polyarthra,	0	0	0	0	0	0	pr.	0	0	0	pr.	0
Crustacea,	0	0	0	pr.	0	0	0	pr.	pr.	pr.	0	0
Bosmina,	0	0	0	0	0	0	0	0	0	0	0	0
Cyclops,	pr.	0	0	pr.	0	0	0	pr.	pr.	pr.	0	0
Daphnia,	0	0	0	0	0	0	0	0	pr.	pr.	0	0
Miscellaneous. Zoöglœa,	0	0	46	0	204	1	5	36	3	0	9	0
TOTAL,	19,845	2,280	130	39	225	1	284	200	37	423	99	376

LYNN.

Microscopical Examination of Water from Walden Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct	Oct.	Nov.	Dec.
Day of examination,	27	3	11	18	24	1	8	15	22	30	5	10
Number of sample,	7861	7894	7912	7954	7975	7979	8028	8109	8156	8168	8215	8319
PLANTS.												
Diatomaceæ,	0	0	0	0	0	0	6	13	0	4	264	0
Synedra,	0	0	0	0	0	0	0	0	0	4	264	0
Tabellaria,	0	0	0	0	0	0	6	13	0	0	0	0
Cyanophyceæ,	25	174	524	117	279	420	1,408	2,191	524	278	124	21
Anabæna,	pr.	0	2	1	116	0	1,064	1,324	266	98	32	0
Anabæna spores,	0	0	0	0	0	0	188	0	70	84	0	0
Chroöcoccus,	0	0	16	0	0	0	0	0	0	0	0	0
Clathrocystis,	10	174	448	60	112	322	124	198	108	48	50	21
Cœlosphærium,	0	0	36	32	48	0	0	1	0	0	pr.	0
Microcystis,	15	0	22	24	3	87	32	0	80	48	34	0
Nostoc,	0	0	0	0	0	11	0	0	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	668	0	0	8	0
Algæ,	31	85	134	159	85	19	9	377	13	77	76	26
Chlorococcus,	16	0	1	0	3	9	0	0	0	12	pr.	18
Closterium,	2	0	0	7	6	1	3	3	5	62	72	5
Dictyosphærium,	0	0	0	0	0	0	0	336	0	0	0	0
Pandorina,	2	0	0	0	0	0	0	0	0	0	0	0
Pediastrum,	10	56	100	36	8	9	6	13	4	3	2	2
Protococcus,	0	25	19	108	8	0	0	0	0	0	1	0
Staurastrum,	1	0	0	0	0	0	0	0	0	0	0	0
Volvox,	0	0	0	1	0	0	0	22	0	0	1	0
Zoöspores,	0	4	14	7	60	0	0	3	4	0	pr.	1
Fungi. Crenothrix,	pr.	0	1	6	1	2	0	7	1	1	5	0
ANIMALS.												
Rhizopoda. Actinophrys,	0	0	0	0	0	0	0	0	0	0	0	0
Infusoria,	8	18	88	161	74	5	3	36	1	26	38	39
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	0
Glenodinium,	0	0	0	0	0	0	0	0	0	0	0	0
Monas,	0	0	0	4	0	0	0	2	0	0	0	0
Peridinium,	1	0	0	1	0	0	0	0	0	0	2	39
Synura,	0	0	0	0	0	0	0	0	0	1	0	0
Trachelomonas,	7	18	88	156	74	5	3	34	1	25	36	0
Vermes. Polyarthra,	0	0	0	0	3	1	0	0	0	0	0	0
Crustacea,	pr.	pr.	0	pr.	0	0	pr.	pr.	pr.	0	0	0
Bosmina,	0	pr.	0	0	0	0	0	0	0	0	0	0
Cyclops,	pr.	pr.	0	pr.	0	0	pr.	pr.	pr.	0	0	0
Daphnia,	pr.	pr.	0	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	60	200	124	544	188	0	0	364	110	152	30	0
TOTAL,	124	477	871	987	630	447	1,426	3,008	649	538	537	86

Chemical Examination of Water from Glen Lewis Pond, Lynn.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
6892	Jan. 14	Jan. 15	Decided.	Cons., green.	0.50	3.75	1.45	.0024	.1160	.0258	.0902	.34	.0000	.0001	1.1
6908	Jan. 17	Jan. 17	Distinct.	Slight.	0.60	-	-	.0448	.0780	.0410	.0370	-	.0300	.0002	-
6909	Jan. 17	Jan. 17	Slight	Slight.	0.90	-	-	.0688	.0372	.0370	.0002	-	.0250	.0003	-
7016	Feb. 12	Feb. 13	None.	V. slight.	0.10	3.00	0.80	.0000	.0064	.0046	.0018	.31	.0050	.0000	0.9
7082	Feb. 27	Mar. 3	Slight.	V. slight.	0.05	2.40	0.95	.0074	.0252	.0128	.0124	.22	.0040	.0001	0.5
7112	Mar. 10	Mar. 11	V. slight.	None.	0.25	3.30	1.30	.0010	.0044	.0038	.0006	.41	.0090	.0000	0.6
7221	Apr. 15	Apr. 16	Slight.	Slight.	0.40	3.25	1.50	.0040	.0314	.0188	.0126	.33	.0200	.0002	0.5
7318	May 13	May 14	Decided.	Slight, green.	0.50	3.50	1.25	.0204	.0422	.0284	.0138	.36	.0050	.0001	0.8
7431	June 10	June 12	Decided.	Cons., green.	0.45	3.85	2.05	.0014	.0658	.0346	.0312	.28	.0070	.0001	0.6
7793	Aug. 12	Aug. 13	Distinct.	Cons.	0.70	5.05	2.60	.0384	.0438	.0402	.0036	.28	.0050	.0001	0.5
7829	Aug. 19	Aug. 20	Slight.	V. slight.	0.65	-	-	.0410	.0440	.0410	.0030	.32	.0050	.0003	0.5
7863	Aug. 26	Aug. 27	Slight.	Slight.	0.85	-	-	.0770	.0514	.0474	.0040	-	.0050	.0000	-
7893	Sept. 2	Sept. 3	Slight.	Slight.	1.20	-	-	.0806	.0540	.0450	.0090	.34	.0090	.0001	0.5
7915	Sept. 10	Sept. 11	Distinct.	Slight.	1.00	-	-	.0504	.0672	.0544	.0128	-	.0100	.0003	-
7956	Sept. 17	Sept. 18	Decided.	Cons., green.	0.90	4.75	2.60	.0000	.0906	.0532	.0374	.37	.0050	.0000	0.6
7974	Sept. 23	Sept. 24	Distinct.	Cons.	0.70	-	-	.0128	.0606	.0506	.0100	-	.0100	.0001	-
7978	Sept. 30	Sept. 30	Distinct.	Cons., green.	0.75	4.80	2.25	.0110	.0594	.0446	.0148	.35	.0070	.0001	0.5
8027	Oct. 7	Oct. 8	Distinct.	Heavy, rusty.	1.40	-	-	.0198	.0730	.0556	.0174	-	.0050	.0000	-
8108	Oct. 14	Oct. 15	Slight.	Cons.	0.90	-	-	.0460	.0580	.0510	.0070	-	.0100	.0001	-
8155	Oct. 21	Oct. 22	Slight.	Slight.	1.10	-	-	.0776	.0582	.0500	.0082	-	.0050	.0000	-
8170	Oct. 28	Oct. 29	V. slight.	Cons.	1.10	4.05	1.40	.1030	.0542	.0422	.0120	.36	.0120	.0005	0.3
8213	Nov. 4	Nov. 5	V. slight.	Cons.	1.10	4.35	1.90	.1060	.0606	.0508	.0098	.41	.0150	.0008	0.3
8316	Dec. 9	Dec. 10	V. slight.	V. slight.	0.85	4.35	2.50	.0560	.0418	.0360	.0058	.36	.0400	.0003	0.9
Av.	....	....	....	....	0.63	3.90	1.75	.0328	.0484	.0324	.0160	.34	.0124	.0002	0.6

Odor, generally distinctly or strongly vegetable, frequently mouldy or unpleasant, often disagreeable.——The samples were collected from the pond near the gate-house, one foot beneath the surface, with the exception of No. 6909, which was collected from near the bottom, and is omitted from the average.

NOTE.—In this and preceding tables, where more than one sample has been taken in a month, the mean analysis for that month has been used in making the average given at the bottom of the table.

LYNN.

Microscopical Examination of Water from Glen Lewis Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Jan.	Jan.	Feb.	Mar.	Mar.	Apr.	May.	June.	Aug.	Aug.	Aug.
Day of examination,	15	19	20	14	5	12	17	14	12	13	20	27
Number of sample,	6892	6908	6909	7016	7082	7112	7221	7318	7431	7793	7829	7863
PLANTS.												
Diatomaceæ,	0	4	pr.	0	0	19	16	0	0	0	2	4
Gomphonema,	0	0	0	0	0	pr.	0	0	0	0	0	0
Melosira,	0	4	0	0	0	9	2	0	0	0	2	0
Meridion,	0	0	0	0	0	10	0	0	0	0	0	0
Navicula,	0	0	0	0	0	0	2	0	0	0	0	2
Synedra,	0	0	pr.	0	0	0	12	0	0	0	0	0
Tabellaria,	0	0	pr.	0	0	0	0	0	0	0	pr.	2
Cyanophyceæ,	0	0	0	0	0	0	0	pr.	1,548	112	9	0
Anabæna,	0	0	0	0	0	0	0	0	0	112	9	0
Nostoc,	0	0	0	0	0	0	0	pr.	860	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	688	0	0	0
Algæ,	0	0	0	0	4	0	308	140	64	0	1	161
Chlorococcus,	0	0	0	0	0	0	2	62	62	0	pr.	161
Closterium,	0	0	0	0	4	0	54	0	2	0	0	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	0	1	0
Protococcus,	0	0	0	0	0	0	0	78	0	0	0	0
Zoöspores,	0	0	0	0	0	0	252	0	0	0	0	0
Fungi,	0	0	5	0	0	0	1	0	0	34	5	6
Cladothrix,	0	0	0	0	0	0	0	0	0	0	0	0
Crenothrix,	0	0	5	0	0	0	1	0	0	34	5	6
ANIMALS.												
Infusoria,	2,200	1,284	10	8	196	1	120	6	1	pr.	6	17
Cryptomonas,	2,200	1,284	9	6	136	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	0	0	0	6	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	0	0	0
Peridinium,	0	0	1	2	60	1	120	0	0	0	6	0
Synura,	0	0	0	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	0	1	pr.	0	17
Vorticella,	0	0	0	0	0	0	0	0	0	0	0	0
Vermes,	0	pr.	0	0	0	0	4	10	0	0	pr.	0
Anuræa,	0	0	0	0	0	0	1	0	0	0	0	0
Polyarthra,	0	pr.	0	0	0	0	3	10	0	0	pr.	0
Crustacea,	0	pr.	0	0	0	0	0	pr.	0	pr.	0	0
Cyclops,	0	pr.	0	0	0	0	0	0	0	pr.	0	0
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	0	0	0	0	642	0	152	15	7	0	30	24
TOTAL,	2,200	1,288	15	8	842	20	601	171	1,620	146	53	212

LYNN.

Microscopical Examination of Water from Glen Lewis Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1891.										
	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct.	Oct.	Nov.	Dec.
Day of examination,	3	11	18	24	1	8	15	22	30	5	10
Number of sample,	7893	7915	7956	7974	7978	8027	8108	8155	8170	8213	8316
PLANTS.											
Diatomaceæ,	**1**	**10**	**2**	**1**	**3**	**15**	**0**	**1**	**37**	**41**	**pr.**
Gomphonema,	0	0	0	0	0	2	0	0	16	pr.	0
Melosira,	0	0	0	0	0	0	0	0	0	36	0
Meridion,	1	0	2	0	0	0	0	1	3	2	0
Navicula,	0	0	0	0	1	13	0	0	11	1	0
Synedra,	0	0	0	1	0	0	0	0	1	2	pr.
Tabellaria,	0	10	0	0	2	0	0	0	6	pr.	pr.
Cyanophyceæ,	**17**	**0**	**4**	**0**	**9**	**1**	**0**	**0**	**0**	**0**	**0**
Anabæna,	0	0	4	0	0	1	0	0	0	0	0
Nostoc,	17	0	0	0	9	0	0	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	0	0	0
Algæ,	**2,089**	**5,952**	**4,737**	**750**	**224**	**20**	**1**	**5**	**602**	**260**	**264**
Chlorococcus,	0	0	0	0	190	0	0	5	6	0	0
Closterium,	1	0	17	6	5	1	1	0	0	0	pr.
Dictyosphærium,	0	0	0	0	29	19	0	0	0	0	0
Protococcus,	2,088	5,952	4,720	744	0	0	0	0	596	260	264
Zoöspores,	0	0	0	0	0	0	0	0	0	0	0
Fungi,	**3**	**24**	**33**	**92**	**5**	**7**	**0**	**1**	**1**	**2**	**1**
Cladothrix,	0	24	0	0	0	0	0	0	0	0	0
Crenothrix,	3	0	33	92	5	7	0	1	1	2	1
ANIMALS.											
Infusoria,	**76**	**2**	**7**	**28**	**29**	**111**	**7,020**	**1**	**0**	**1**	**pr.**
Cryptomonas,	0	0	0	1	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	1	0	0	0	0	pr.	0
Monas,	0	0	0	3	1	7	0	0	0	0	0
Peridinium,	0	0	0	4	6	0	0	0	0	pr.	pr.
Synura,	0	0	0	0	20	96	7,020	1	0	0	0
Trachelomonas,	76	2	7	2	1	8	0	pr.	0	1	0
Vorticella,	0	0	0	18	0	0	0	0	0	0	0
Vermes,	**0**	**2**	**3**	**0**	**0**	**1**	**0**	**0**	**0**	**pr.**	**0**
Anurea,	0	0	3	0	0	1	0	0	0	pr.	0
Polyarthra,	0	2	0	0	0	0	0	0	0	0	0
Crustacea,	**pr.**	**0**	**0**	**pr.**	**pr.**	**pr.**	**pr.**	**pr.**	**pr.**	**pr.**	**0**
Cyclops,	pr.	0	0	pr.	pr.	pr.	pr.	pr.	pr.	0	0
Daphnia,	pr.	0	0	0	0	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	**248**	**0**	**81**	**536**	**188**	**552**	**12**	**121**	**88**	**40**	**34**
TOTAL,	2,434	5,990	4,867	1,407	438	707	7,033	129	728	344	299

LYNN.

Chemical Examination of Water from the Canal of the Lynn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid Total.	Ammonia. Albuminoid Dissolved.	Ammonia. Albuminoid Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6933	Jan. 21	Jan. 22	V. slight.	Slight.	0.55	4.30	1.40	.0058	.0130	.0120	.0010	.37	.0150	.0001	1.1
7012	Feb. 12	Feb. 13	V. slight.	V. slight.	0.35	3.90	1.05	.0030	.0096	.0076	.0020	.34	.0070	.0001	1.4
7108	Mar. 10	Mar. 11	Slight.	V. slight.	0.70	4.35	1.90	.0256	.0282	.0212	.0070	.41	.0180	.0002	1.8
7314	May 13	May 14	V. slight.	Slight.	0.75	4.80	1.50	.0000	.0192	.0178	.0014	.41	.0100	.0000	1.9
Av.	....	....	....	....	0.59	4.34	1.46	.0086	.0175	.0146	.0029	.38	.0125	.0001	1.6

Odor of No. 6933, faintly vegetable; of No. 7012, none; of No. 7108, distinctly vegetable and unpleasant, becoming disagreeable on heating; of No. 7314, distinctly vegetable. —— The samples where collected from the canal which conveys water from Hawkes Brook and Penny Brook, on which Walden and Glen Lewis ponds are situated, to Birch Pond or to the pumping station.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	May.
Day of examination,	22	14	12	14
Number of sample,	6933	7012	7108	7314
PLANTS.				
Diatomaceæ,	3	12	9	1
Meridion,	0	4	4	0
Navicula,	1	pr.	2	1
Nitzschia,	2	6	0	0
Synedra,	pr.	2	3	pr.
Fungi. Crenothrix,	1	3	32	22
ANIMALS.				
Infusoria. Dead infusoria,	0	0	9	0
Miscellaneous. Zoöglœa,	8	32	270	66
TOTAL,	12	47	320	89

LYNN.

Table showing the Average Depth of Water in Feet in the Ponds and Storage Reservoirs of the Lynn Water Works, during the Weeks in which Samples of Water were collected for Analysis.

Week Ending—	Breed's Pond. High Water, 21.00 feet.	Birch Pond. High Water, 21.75 feet.	Walden Pond. High Water, 16.00 feet.	Glen Lewis Pond. High Water, 17.00 feet.
Jan. 17,	19.3	16.4	16.6	17.0
Feb. 14,	20.7	18.6	17.0	17.2
Feb. 28,	20.8	19.6	17.1	17.3
Mar. 14,	21.1	20.7	17.1	17.3
Apr. 18,	20.5	21.9	16.3	17.2
May 16,	19.4	21.6	15.5	17.1
June 13,	19.1	19.9	14.8	17.1
July 25,	19.0	15.4	13.3	17.1
Aug. 15,	17.0	14.5	12.8	17.0
Aug. 22,	16.2	14.2	12.1	17.0
Aug. 29,	15.6	13.9	12.1	17.1
Sept. 5,	14.7	13.5	11.0	17.0
Sept. 12,	13.9	13.8	11.0	17.2
Sept. 19,	12.9	13.3	11.0	17.1
Sept. 26,	11.9	12.6	10.8	17.1
Oct. 3,	11.4	12.1	10.7	17.1
Oct. 10,	10.8	11.8	10.7	17.1
Oct. 17,	10.8	11.3	11.0	17.2
Oct. 24,	11.1	10.3	11.2	17.2
Oct. 31,	11.3	9.3	11.2	17.2
Nov. 7,	11.2	8.2	11.3	17.2
Dec. 12,	12.7	9.7	8.1	17.2

Water Supply of Malden, Medford and Melrose.

Chemical Examination of Water from Spot Pond, Stoneham.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1891.														
6875	Jan. 6	Jan. 7	V. slight.	V. slight.	0.35	3.75	1.35	.0016	.0162	.0150	.0012	.45	.0300	.0001	1.8
6981	Feb. 3	Feb. 5	Distinct.	Cons.	0.25	4.05	1.75	.0030	.0198	.0170	.0028	.43	.0150	.0003	1.7
7088	Mar. 3	Mar. 5	V. slight.	V. slight	0.25	3.50	0.85	.0030	.0144	.0140	.0004	.44	.0100	.0000	1.4
7193	Apr. 7	Apr. 8	V. slight.	V. slight.	0.30	3.85	1.45	.0000	.0142	.0140	.0002	.43	.0050	.0000	1.1
7292	May 5	May 7	Slight.	V. slight.	0.30	3.55	1.25	.0000	.0202	.0178	.0024	.45	.0030	.0000	1.3
7390	June 2	June 4	Slight.	Slight.	0.20	3.55	1.25	.0008	.0216	0182	.0034	.41	.0020	.0001	1.1
7537	July 6	July 7	Slight.	Cons.	0.20	3.25	1.20	.0002	.0202	.0184	.0018	.41	.0050	.0001	1.3
7784	Aug. 10	Aug. 12	Distinct.	Slight.	0.15	3.70	1.05	.0002	.0172	.0142	.0030	.37	.0060	.0000	1.3
7887	Sept. 2	Sept. 3	V. slight.	Slight.	0.15	3.45	1.05	.0004	.0218	.0198	.0020	.42	.0100	.0000	1.1
8016	Oct. 5	Oct. 7	Slight.	Slight.	0.10	4.25	1.35	.0000	.0220	.0194	.0026	.44	.0030	.0001	1.3
8222	Nov. 4	Nov. 6	V. slight.	V. slight.	0.10	3.65	1.25	.0000	.0166	.0148	.0018	.48	.0050	.0000	1.3
8303	Dec. 3	Dec. 4	Slight.	Cons.	0.15	3.85	1.45	.0000	.0152	.0110	.0042	.45	.0050	.0000	1.6
Av.	....	....	....	....	0.21	3.70	1.27	.0008	.0183	.0161	.0022	.43	.0082	.0001	1.4

Odor, generally faintly vegetable or none. In June and July, decidedly vegetable and grassy.—The samples were collected from the pond at the pumping station of the Malden water works, with the exception of No. 8303, which was collected from a faucet at city hall, Malden.

MALDEN.

Microscopical Examination of Water from Spot Pond, Stoneham.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	5	6	10	13	4	8	13	3	7	7	5
Number of sample,	6875	6981	7088	7193	7292	7390	7537	7784	7887	8016	8222	8303
PLANTS.												
Diatomaceæ,	53	1	4	70	102	88	14	464	231	67	160	217
Asterionella,	8	0	0	8	17	36	2	410	25	3	102	110
Cyclotella,	0	0	0	0	14	2	0	12	15	0	5	22
Diatoma,	0	0	0	3	3	2	0	0	0	0	0	pr.
Melosira,	2	0	0	4	31	0	0	7	18	7	27	12
Navicula,	0	0	0	3	1	0	0	0	pr.	1	0	4
Stephanodiscus,	41	0	3	1	16	39	0	0	pr.	0	0	0
Synedra,	0	pr.	0	40	7	1	3	0	1	10	5	16
Tabellaria,	2	1	1	11	13	8	9	35	172	46	21	53
Cyanophyceæ,	0	0	0	0	0	21	4	23	20	0	11	9
Chroöcoccus,	0	0	0	0	0	4	3	23	0	0	0	8
Microcystis,	0	0	0	0	0	0	0	pr.	20	0	11	1
Nostoc,	0	0	0	0	0	17	1	0	0	0	0	0
Algæ,	2	2	0	0	5	98	26	4	0	14	1	18
Chlorococcus,	0	2	0	0	3	10	26	0	0	0	0	16
Conferva,	0	0	0	0	0	pr.	pr.	0	0	14	0	0
Nephrocytium,	0	0	0	0	0	86	0	0	0	0	0	0
Raphidium,	2	0	0	0	2	2	0	4	0	0	1	2
Fungi. Crenothrix,	2	0	1	0	1	0	1	0	1	0	0	6
ANIMALS.												
Rhizopoda,	pr.	1	0	2	0	pr.	0	0	pr.	1	0	6
Actinophrys,	pr.	0	0	0	0	pr.	0	0	pr.	1	0	0
Difflugia,	0	1	0	2	0	0	0	0	0	0	0	6
Infusoria,	pr.	1	1	5	0	pr.	5	1	5	9	5	9
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	2	0
Dinobryon,	0	0	0	5	0	0	0	0	0	1	pr.	8
Dinobryon cases,	0	0	0	0	0	0	0	0	0	0	2	0
Glenodinium,	0	0	0	0	0	0	5	0	1	0	0	pr.
Peridinium,	0	1	1	0	0	0	0	1	1	0	0	pr.
Trachelomonas,	pr.	0	0	0	0	pr.	0	0	3	8	1	1
Vermes. Anuræa,	0	0	0	0	0	0	pr.	1	0	0	1	pr.
Crustacea. Cyclops,	0	0	pr.	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	2	160	154	226	170	1	40	66	200	284	64	27
TOTAL,	59	165	160	303	278	208	90	559	457	375	262	292

MALDEN.

Table showing Heights of Water in Spot Pond at the Times when Samples of Water were collected for Analysis.

NOTE. — Heights are in feet above or below high-water mark. The sign + indicates "above high water." The sign – indicates "below high water."

DATE.	Height of Water.	DATE.	Height of Water.
1891.		1891 — Con.	
Jan. 6,	–1.9	July 6,	–1.8
Feb. 3,	–0.8	Aug. 10,	–3.0
Mar. 3,	+0.2	Sept. 2,	–3.8
Apr. 7,	+0.2	Oct. 5,	–5.1
May 5,	–0.4	Nov. 4,	–5.8
June 2,	–1.0	Dec. 3,	–6.6

Chemical Examination of Water from Doleful Pond, Stoneham.

[Parts per 100,000.]

Number.	DATE OF		APPEARANCE.			RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1891.														
8268	Nov. 19	Nov. 20	Decided.	Heavy.	1.30	5.75	2.90	.0008	.0520	.0296	.0224	.61	.0100	.0001	1.4

Odor, vegetable, becoming stronger on heating. —— The sample was collected from the pond. Water flows from this pond into Spot Pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 580; *Diatoma*, 3; *Fragilaria*, 4; *Melosira*, 108; *Navicula*, 5; *Pinnularia*, 1; *Synedra*, 368; *Tabellaria*, 1. Cyanophyceæ, *Chroöcoccus*, 33; *Clathrocystis*, 6; *Microcystis*, 4; *Tetrapedia*, 1. Algæ, *Characium*, 8; *Chlorococcus*, 51; *Closterium*, 13; *Raphidium*, 32; *Scenedesmus*, 8; *Staurogenia*, 1; *Tetraspora*, 8,064. Infusoria, *Monas*, 5; *Peridinium*, 1. Vermes, *Rotatorian ova*, 3. Total, 9,300.

MALDEN.

WATER SUPPLY OF MALDEN.

Chemical Examination of Water from Tubular Wells at Webster Park (Eaton's Meadows), Malden.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
6876	Jan. 6	Jan. 7	None.	None.	0.00	18.30	.0000	.0006	2.10	.5500	.0001	8.4
6982	Feb. 3	Feb. 5	None.	None.	0.00	19.25	.0002	.0010	2.40	.5500	.0001	9.1
7089	Mar. 3	Mar. 5	None.	None.	0.00	19.70	.0002	.0008	2.33	.5250	.0000	9.6
7194	Apr. 7	Apr. 8	None.	None.	0.00	20.70	.0000	.0010	2.18	.4750	.0000	8.6
7291	May 5	May 7	None.	None.	0.00	20.60	.0000	.0000	2.16	.5000	.0000	9.6
7389	June 2	June 4	None.	None.	0.00	21.85	.0000	.0000	2.20	.4500	.0001	9.7
7494	June 26	June 27	None.	None.	0.00	22.00	.0000	.0000	2.20	.4750	.0001	10.3
7538	July 6	July 7	None.	None.	0.00	21.60	.0002	.0008	2.20	.5000	.0000	10.0
7783	Aug. 10	Aug. 12	None.	None.	0.00	21.30	.0000	.0014	-	-	.0001	8.7
7888	Sept. 2	Sept. 3	Slight, clayey.	None.	0.08	22.00	.0010	.0010	2.10	.5500	.0001	9.6
8017	Oct. 5	Oct. 7	None.	None.	0.00	21.00	.0000	.0010	2.04	.5250	.0000	10.3
8221	Nov. 4	Nov. 6	None.	V. slight.	0.00	21.80	.0000	.0006	2.48	.5500	.0001	10.6
8304	Dec. 3	Dec. 4	V. slight, clayey.	Slight, earthy.	0.00	20.70	.0000	.0014	2.38	.5250	.0000	10.6
Av.	....	....	....	....	0.00	20.83	.0001	.0007	2.23	.5146	.0001	9.6

Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	5	6	10	12	4	27	8	13	3	7	7	5
Number of sample,	6876	6982	7089	7194	7291	7389	7494	7538	7783	7888	8017	8221	8304
PLANTS.													
Diatomaceæ,	0	0	11	22	0	0	0	0	0	0	0	0	0
Stephanodiscus,	0	0	0	10	0	0	0	0	0	0	0	0	0
Synedra,	0	0	11	4	0	0	0	0	0	0	0	0	0
Tabellaria,	0	0	0	8	0	0	0	0	0	0	0	0	0
Cyanophyceæ. Nostoc spores,	0	0	0	0	0	0	16	0	0	0	0	0	0
Fungi. Crenothrix,	0	0	0	0	0	0	0	0	0	9	0	0	0
ANIMALS.													
Rhizopoda. Difflugia,	0	0	0	2	0	0	0	0	0	0	0	0	0
Infusoria. Dinobryon,	0	0	0	22	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	0	0	0	118	0	pr.	0	0	8	86	0	0	36
TOTAL,	0	0	11	164	0	pr.	16	0	8	95	0	0	36

WATER SUPPLY OF MARBLEHEAD.

Chemical Examination of Water from the Wells of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
6874	Jan. 6	Jan. 7	V. slight.	None.	0.0	99.30	.0086	.0014	37.20	.0350	.0002	43.5
7456	June 15	June 16	V. slight.	Slight, rusty.	0.0	39.10	.0030	.0002	9.98	.0850	.0005	12.9
6966	Jan. 31	Feb. 3	Slight.	Slight, earthy.	0.0	12.70	.0040	.0072	2.05	.1650	.0002	5.9
7457	June 15	June 16	None.	V. slight.	0.0	13.70	.0004	.0034	1.60	.1250	.0030	4.9
7752	Aug. 3	Aug. 4	None.	V. slight.	0.0	6.35	.0014	.0032	2.03	.0200	.0003	4.6
7910	Sept. 9	Sept. 10	None.	None.	0.0	33.00	.0000	.0006	9.30	.1000	.0000	12.6
8032	Oct. 8	Oct. 12	None.	None.	0.0	38.50	.0000	.0000	11.14	.0750	.0000	14.8
8285	Nov. 29	Dec. 2	None.	None.	0.0	17.90	.0000	.0010	3.78	.1500	.0000	8.4
8372	Dec. 29	Dec. 30	None.	None.	0.0	20.80	.0000	.0010	3.20	.1500	.0000	10.0

Odor, none.——The first two samples (Nos. 6874 and 7456) were collected from a faucet at the pumping station and represent water drawn from the tubular wells only. The next three samples (Nos. 6966, 7457 and 7752) were collected from the large well; this well is located farther from tide water than any of the tubular wells. The remaining samples were collected from a faucet in the town, and represent a mixture of the water of the large well and a varying number of tubular wells.

On account of the proximity of this supply to tide water the character of the water varies greatly in the different wells and also in each well at different times.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	1891. June.	1891. Feb.	1891. June.	1891. Aug.	1891. Sept.	1891. Oct.	1891. Dec.	1892. Jan.
Day of examination,	7	16	4	16	5	11	12	3	2
Number of sample,	6874	7456	6966	7457	7752	7910	8032	8285	8372
PLANTS.									
Diatomaceæ,	1	277	0	13	4	1	pr.	2	0
Melosira,	1	2	0	0	0	1	0	0	0
Nitzschia,	0	7	0	0	0	0	0	0	0
Synedra,	0	176	0	10	4	pr.	pr.	2	0
Tabellaria,	0	92	0	3	pr.	0	0	pr.	0
Fungi. Crenothrix,	0	0	0	0	0	0	0	2	1
ANIMALS.									
Infusoria. Paramæcium,	0	0	1	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	238	0	11	44	pr.	pr.	0	7	27
TOTAL,	239	277	12	57	4	1	pr.	11	28

MARBLEHEAD.

Chemical Examination of Water from a Tubular Well near the Pumping Station of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1891.												
7199	Apr. 9	Apr. 11	Decided.	Cons.	0.0	45.50	.0292	.0020	12.40	.0070	.0001	16.4	-
7262	May 1	May 2	Decided.	Heavy.	0.0	29.60	.0170	.0014	7.75	.0030	.0002	11.8	.6794
7261	May 1	May 2	Decided.	Heavy, like iron rust.	0.0	15.00	.0150	.0004	2.19	.0070	.0001	6.1	.8138

Odor, none. —— The samples were collected from a flowing well near the pumping station, the first two being filled directly from the well, and the last from a little pool beside the well, into which the water flowed. This well is not connected with the water supply system, and the samples were collected on account of the peculiar character of the water from the well.

Microscopical Examination.

No. 7199. Diatomaceæ, *Navicula*, 5; *Stephanodiscus*, 2. Fungi, *Crenothrix*, 32. Total organisms, 39.
No. 7262. No organisms.
No. 7261. No organisms.

Chemical Examination of Surface Water Sources in the vicinity of the Wells of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6967	Jan. 31	Feb. 3	Decided.	Cons.	1.30	7.50	2.65	.0506	.0398	.0260	.0138	.87	.0110	.0007	2.6
7197	Apr. 9	Apr. 11	Slight.	Cons.	0.75	8.60	2.90	.0038	.0324	.0282	.0042	.95	.0150	.0001	3.1
7198	Apr. 9	Apr. 11	Distinct.	Slight.	0.60	6.85	2.35	.0070	.0346	.0266	.0080	.78	.0150	.0002	2.7

Odor of No. 6967, vegetable and musty, becoming much stronger on heating; of No. 7197, very disagreeable; of No. 7198, vegetable and disagreeable. —— Sample No. 6967 was collected from the pond near the pumping station; No. 7197 from a brook which crosses Salem Street in Swampscott near the Marblehead line. No. 7198 was from a pond near Cabot Childs' house on the Swampscott road. This pond is said to have an area of about three acres and its maximum depth is said to be eighteen feet.

MARBLEHEAD.

Microscopical Examination of Surface Water Sources in the vicinity of the Wells of the Marblehead Water Works.

[Number of organisms per cubic centimeter.]

	1891.		
	February.	April.	April.
Day of examination,	4	13	13
Number of sample,	6967	7197	7198
PLANTS.			
Diatomaceæ,	1	58	46
Meridion,	0	2	0
Navicula,	1	48	0
Nitzschia,	0	4	0
Synedra,	0	2	46
Tabellaria,	0	2	0
Algæ,	3	8	5
Closterium,	0	0	5
Protococcus,	3	4	0
Zoöspores,	0	4	0
Fungi. Crenothrix,	122	154	128
ANIMALS.			
Rhizopoda,	2	1	34
Actinophrys,	0	1	0
Arcella,	pr.	0	0
Difflugia,	2	0	34
Infusoria,	55	1	118
Cryptomonas,	11	0	0
Dinobryon,	0	0	18
Euglena,	0	1	0
Monas,	1	0	2
Paramæcium,	0	0	pr.
Peridinium,	33	0	62
Trachelomonas,	10	0	36
Uroglena volvox,	pr.	0	0
Vermes,	pr.	pr.	1
Anurea,	0	pr.	1
Asplanchna,	0	0	pr.
Polyarthra,	pr.	0	pr.
Rotifer,	pr.	0	0
Synchæta,	pr.	0	pr.
Crustacea. Bosmina,	pr.	0	0
Miscellaneous. Zoöglœa,	1,149	234	378
TOTAL,	1,329	446	710

MARLBOROUGH.

WATER SUPPLY OF MARLBOROUGH.

Chemical Examination of Water from Lake Williams, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6904	Jan. 15	Jan. 16	None.	V.slight.	0.03	4.20	1.15	.0012	.0204	.0190	.0014	.47	.0120	.0001	1.9
7017	Feb. 12	Feb. 13	Slight.	V.slight.	0.05	4.00	0.75	.0000	.0162	.0116	.0046	.46	.0120	.0001	1.9
7096	Mar. 6	Mar. 7	V.slight.	Slight.	0.05	4.10	1.10	.0024	.0138	.0126	.0012	.49	.0250	.0001	1.7
7242	Apr. 23	Apr. 23	V.slight.	Slight.	0.03	3.20	0.95	.0014	.0182	.0144	.0038	.41	.0050	.0000	1.8
7321	May 14	May 15	Slight.	Slight.	0.03	4.00	1.25	.0014	.0264	.0204	.0060	.43	.0070	.0000	1.9
7422	June 9	June 10	V.slight.	Slight.	0.01	3.95	1.25	.0016	.0198	.0168	.0030	.33	.0060	.0000	1.7
7495	June 26	June 27	Slight.	Slight.	0.05	4.30	1.30	.0000	.0214	.0178	.0036	.42	.0020	.0002	1.6
7565	July 15	July 16	Distinct.	Slight.	0.15	4.40	1.35	.0000	.0238	.0156	.0082	.44	.0050	.0000	1.7
7844	Aug. 21	Aug. 24	Distinct.	Slight.	0.02	4.20	1.60	.0008	.0204	.0176	.0028	.45	.0000	.0001	1.6
7917	Sept. 10	Sept. 11	V.slight	V.slight	0.05	4.05	1.05	.0014	.0206	.0176	.0030	.44	.0050	.0000	1.7
8137	Oct. 16	Oct. 17	V.slight.	V.slight.	0.08	4.25	1.25	.0006	.0178	.0148	.0030	.46	.0050	.0001	1.8
8234	Nov. 6	Nov. 7	V.slight.	Slight.	0.02	4.30	1.25	.0004	.0210	.0182	.0028	.46	.0090	.0000	1.8
8322	Dec. 10	Dec. 11	V.slight.	V.slight.	0.05	4.15	1.40	.0000	.0160	.0138	.0022	.44	.0000	.0000	1.7
Av.	....	....	....	....	0.05	4.12	1.20	.0009	.0197	.0162	.0035	.45	.0072	.0001	1.8

Odor, distinctly vegetable, frequently unpleasant or disagreeable, sometimes none; in June, very disagreeable.—— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

[Number of organisms per cubic centimeter]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	14	11	28	16	11	27	16	24	12	17	10	11
Number of sample,	6904	7017	7096	7242	7321	7422	7495	7565	7844	7917	8137	8234	8322
PLANTS.													
Diatomaceæ,	**193**	pr.	**17**	**308**	**98**	**23**	**166**	**790**	**179**	**48**	**17**	**189**	**136**
Asterionella,	115	0	1	56	2	0	24	30	0	4	11	170	116
Fragilaria,	0	0	0	0	0	0	0	13	0	13	0	2	2
Melosira,	3	0	0	6	0	0	0	1	0	0	0	0	0
Navicula,	pr.	0	0	2	pr.	0	pr.	0	pr.	3	0	1	2
Synedra,	10	pr.	16	198	pr.	0	0	18	4	3	0	8	2
Tabellaria,	65	0	0	46	96	23	142	723	175	25	6	8	14

MARLBOROUGH.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.												
	Jan.	Feb.	Mar.	Apr.	May.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.													
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**819**	**13**	**1**	**32**	**0**	**0**	**0**
Chroöcoccus,	0	0	0	0	0	0	812	0	0	25	0	0	0
Microcystis,	0	0	0	0	0	0	3	0	1	7	0	0	0
Nostoc spores,	0	0	0	0	0	0	4	13	0	0	0	0	0
Algæ,	**0**	**0**	**0**	**6**	**9**	**23**	**24**	**12**	**63**	**82**	**0**	**0**	**0**
Chlorococcus,	0	0	0	6	9	23	24	12	53	60	0	0	0
Raphidium,	0	0	0	0	0	0	0	0	10	22	0	0	0
Fungi. Crenothrix,	**0**	**0**	**3**	**0**	**0**	pr.	**0**	**2**	**0**	**0**	**0**	**1**	**0**
ANIMALS.													
Infusoria,	pr.	**0**	pr.	**3**	**6**	**21**	**36**	**1**	**22**	**61**	**2**	**35**	**9**
Ceratium,	0	0	0	0	6	21	35	1	6	4	0	0	0
Dinobryon,	0	0	0	0	0	0	0	0	14	51	2	10	6
Dinobryon cases,	0	0	0	0	0	0	0	0	0	0	0	24	3
Monas,	0	0	pr.	0	0	0	0	0	0	3	0	1	pr.
Peridinium,	pr	0	0	2	0	0	0	0	1	pr.	0	0	pr.
Trachelomonas,	0	0	0	1	0	0	1	pr	1	3	pr.	pr.	0
Crustacea. Cyclops,	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**29**	**0**	**360**	**140**	**7**	**2**	**0**	**167**	**66**	**79**	**1**	**16**	**2**
TOTAL,	222	1	380	457	120	69	1,045	985	331	302	20	241	147

WATER SUPPLY OF BRANT ROCK, MARSHFIELD. — BRANT ROCK WATER COMPANY.

Chemical Examination of Water from the Tubular Well of the Brant Rock Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8183	Nov. 1	Nov. 2	None.	V. slight	0.0	35.50	.0012	.0026	11.50	.1500	.0000	11.1

Odor, none. —— The sample was collected from a faucet in a house near the well.

Microscopical Examination.

Diatomaceæ, *Tabellaria*, pr. **Fungi**, *Crenothrix*, 4. **Miscellaneous**, *Zoöglœa*, pr. **Total**, 4.

WATER SUPPLY OF MEDFORD.

(See *Malden*.)

WATER SUPPLY OF MELROSE.

(See *Malden*.)

PROPOSED WATER SUPPLY OF METHUEN.

Chemical Examination of Water from Harris Pond in Methuen.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
7156	Mar. 28	Mar. 30	V. slight.	Slight.	0.05	3.20	0.80	.0008	.0108	.0094	.0014	.18	.0180	.0000	1.4
7157	Mar. 28	-	-	-	0.25	-	-	-	-	-	-	.21	-	-	-

Odor of No. 7156, very faintly mouldy; of No. 7157, none.——No. 7156 was collected from Harris Pond at its outlet. No. 7157 was collected from the brook at the first dam below Harris Pond.

NOTE. — A small portion of the town of Methuen obtains a supply of water from Lawrence.

Microscopical Examination.

No. 7156. Diatomaceæ, *Cyclotella*, 1; *Meridion*, pr; *Stephanodiscus*, 1; *Synedra*, 14. Algæ, *Protococcus*, pr. Rhizopoda, *Actinophrys*, 1; *Difflugia*, pr. Infusoria, *Dinobryon*, 1; *Glenodinium*, pr.; *Trachelomonas*, pr. Miscellaneous, *Zoöglœa*, 18. Total, 36.

WATER SUPPLY OF MIDDLETON.

(See *Danvers*.)

WATER SUPPLY OF MILLIS. — MILLIS WATER COMPANY.

Description of Works. — The source of supply is the Aqua Rex spring located about half a mile north-east of the village, and a short distance north of the New York & New England Railroad. At the spring a rectangular excavation has been made about 25 feet long, 10 feet wide and 5 feet deep, covered by a wooden building. Outside of the building is an open basin about 30 feet in diameter, into which the overflow from the spring discharges, its surface being from six inches to a foot lower than that of the spring when the latter is not lowered by pumping. Pumps force the water to an open wooden tank which is supported by a wooden trestle. The tank is about 20 feet in diameter and holds 36,000 to 38,000 gallons.

WATER SUPPLY OF MILTON. — MILTON WATER COMPANY.

Description of Works. — Population in 1890, 4,278. This company distributes water throughout the town through cast-iron pipes, but obtains its water supply, by purchase, from the works of the Hyde Park Water Company.

WATER SUPPLY OF THE STATE PRIMARY SCHOOL, MONSON.

Chemical Examination of Water from Reservoirs at the State Primary School, Monson.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7144	Mar. 24	Mar. 26	Slight.	Cons.	0.20	3.75	0.75	.0092	.0184	.0152	.0032	.26	.0600	.0001	1.4
7154	Mar. 28	Mar. 30	V. slight.	V. slight.	0.06	2.70	0.50	.0012	.0050	.0050	.0000	.18	.0220	.0000	1.7
7155	Mar. 27	Mar 30	V. slight.	V. slight.	0.00	1.85	0.50	.0010	.0070	.0040	.0030	.12	.0050	.0000	0.5

Odor, vegetable. —— No. 7144 was collected from a small artificial pond (known as the "ice pond") located on a brook in the valley just west of the buildings. No. 7154 was collected from the west reservoir and No. 7155 from the south reservoir. The supply for the school is drawn mainly from the west and south reservoirs, the ice pond being used as a supplementary supply.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. March.	1891. March.	1891. March.
Day of examination,	26	31	31
Number of sample,	7144	7154	7155
PLANTS.			
Diatomaceæ,	0	2	28
Diatoma,	0	0	2
Melosira,	0	0	3
Navicula,	0	1	4
Synedra,	0	1	15
Tabellaria,	0	0	4
ANIMALS.			
Infusoria,	pr.	4	4
Dinobryon,	0	0	2
Monas,	0	pr.	0
Peridinium,	pr.	4	2
Miscellaneous. Zoöglœa,	0	0	50
TOTAL,	pr.	6	82

NAHANT.

Water Supply of Nahant.

(See *Swampscott. — Marblehead Water Company.*)

Water Supply of Nantucket. — Wannacomet Water Company.

Chemical Examination of Water from Wannacomet Pond, Nantucket.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7758	Aug. 5	Aug. 8	V. dec'd.	Slight.	0.30	6.00	1.90	.0000	.0920	.0336	.0584	-	.0050	.0000	1.1
7837	Aug. 19	Aug. 20	Decided, green.	Heavy, green.	0.40	7.10	2.95	.0006	.0884	.0370	.0514	2.00	.0000	.0001	0.9
7898	Sept. 2	Sept. 3	Decided.	Cons.	0.35	8.00	3.00	.0080	.0876	.0452	.0424	1.90	.0070	.0000	1.6
7946	Sept. 16	Sept. 17	Distinct.	Cons., green.	0.30	7.45	2.15	.0094	.0746	.0452	.0294	1.80	.0050	.0001	1.6
7976	Sept. 23	Sept. 25	Distinct.	Slight.	0.30	8.70	3.20	.0054	.0808	.0474	.0334	1.59	.0070	.0000	1.4
8019	Oct. 5	Oct. 7	Distinct.	Cons.	0.30	6.90	1.90	.0386	.0442	.0322	.0120	1.60	.0070	.0000	1.6
8165	Oct. 21	Oct. 23	V. slight.	Slight.	0.00	5.95	1.50	.0254	.0210	.0150	.0060	1.91	.0100	.0002	1.4
8211	Nov. 3	Nov. 5	V. slight.	V. slight.	0.00	6.25	2.15	.0138	.0236	.0170	.0066	2.05	.0120	.0002	1.6
8309	Dec. 6	Dec. 8	V. slight.	Slight.	0.00	6.55	2.35	.0000	.0174	.0124	.0050	2.00	.0150	.0000	1.3
Av.	....	....	....	....	0.22	7.54	2.33	.0112	.0588	.0317	.0271	1.86	.0076	.0001	1.4

Odor of the August samples, vegetable but not unpleasant, becoming much stronger on heating; of the September samples, both cold and hot, vegetable and unpleasant, increasing until September 23, when it was strongly vegetable, grassy and disagreeable; of the remaining samples, faintly vegetable, disappearing on heating. — The samples were collected from the pond about one foot beneath the surface, near the point from which the supply for the town is drawn.

NOTE. — These samples were collected during a period when the water was affected by a disagreeable taste and odor due to a growth of blue-green algæ. This water was similarly affected, and at about the same season of the year, in the years 1884 and 1889, and less seriously, it is said, in other years.

Microscopical Examination

[Number of organisms per cubic centimeter.]

	1891. Aug.	Aug.	Sept.	Sept.	Sept.	Oct.	Oct.	Nov.	Dec.
Day of examination,	7	20	5	18	25	7	22	5	9
Number of sample,	7758	7837	7898	7946	7976	8019	8165	8211	8309
PLANTS.									
Diatomaceæ,	0	0	18	0	0	0	3	78	52
Cyclotella,	0	0	17	0	0	0	pr.	6	0
Navicula,	0	0	1	0	0	0	1	6	2
Synedra,	0	0	0	0	0	0	2	66	50
Cyanophyceæ,	2,460	2,640	3,792	424	960	168	pr.	10	0
Anabæna,	2,460	2,640	3,792	0	568	88	pr.	1	0
Anabæna spores,	0	0	0	424	392	0	0	0	0
Chroöcoccus,	0	0	0	0	0	4	0	9	0
Nostoc spores,	0	0	0	0	0	76	0	0	0

NANTUCKET.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.								
	Aug.	Aug.	Sept.	Sept.	Sept.	Oct.	Oct.	Nov.	Dec.
PLANTS — Con.									
Algæ,	1	0	219	0	0	13	7	22	6
Arthrodesmus,	0	0	5	0	0	0	0	0	0
Chlorococcus,	1	0	212	0	0	0	7	7	0
Scenedesmus,	0	0	0	0	0	12	pr.	13	4
Staurastrum,	0	0	2	0	0	1	0	2	2
ANIMALS.									
Infusoria,	1	0	4	0	0	0	0	61	2
Dinobryon,	0	0	0	0	0	0	0	45	0
Dinobryon cases,	0	0	0	0	0	0	0	10	1
Peridinium,	0	0	4	0	0	0	0	6	1
Trachelomonas,	1	0	0	0	0	0	0	0	pr.
Vermes. Polyarthra,	1	0	1	0	0	0	0	0	0
Crustacea,	pr.	pr.	pr.	pr.	pr.	0	pr.	pr.	pr.
Cyclops,	pr.	pr.	0	pr.	pr.	0	pr.	pr.	pr.
Daphnia,	pr.	0	pr.	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	21	86	220	264	0	248	108	35	78
TOTAL,	2,484	2,726	4,236	688	960	429	118	206	136

WATER SUPPLY OF NATICK.

Chemical Examination of Water from the South Arm of Pegan Brook, near the point where it enters Dug Pond, Natick.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
									Total.	Dissolved.	Suspended.				
	1891.	1891.													
6975	Feb. 3	Feb. 4	V. slight.	Slight.	0.20	5.70	1.30	.0190	.0144	.0118	.0026	0.66	.1400	.0009	2.9
7078	Mar. 2	Mar. 3	V. slight.	V. slight.	0.15	5.70	1.80	.0270	.0120	.0108	.0012	0.97	.1600	.0012	3.6
7175	Apr. 6	Apr. 7	Slight.	Heavy, earthy.	0.15	7.05	2.15	.0192	.0156	.0110	.0046	0.81	.1250	.0008	2.3
7276	May 4	May 5	Slight.	Heavy.	0.18	8.45	1.50	.0036	.0286	.0190	.0096	1.09	.1700	.0022	3.2
7377	June 1	June 2	Slight.	Slight.	0.08	9.05	2.65	.0020	.0104	.0082	.0022	1.08	.1100	.0025	3.4
7749	Aug. 3	Aug. 4	Slight, milky.	Slight.	0.20	9.20	2.20	.0000	.0144	.0124	.0020	1.32	.0020	.0002	3.6
7869	Aug. 31	Sept. 1	Slight.	Slight.	1.20	10.20	3.25	.0082	.0386	.0342	.0044	0.67	.0600	.0005	3.4
7994	Oct. 1	Oct. 2	V. slight.	V. slight.	0.02	9.45	2.55	.0000	.0086	.0058	.0028	1.18	.1200	.0003	3.4
8192	Nov. 2	Nov. 3	V. slight.	Slight.	0.30	8.60	2.20	.0002	.0220	.0198	.0022	0.91	.1200	.0005	3.5
8282	Dec. 1	Dec. 2	V. slight.	V. slight.	0.40	8.55	2.55	.0122	.0184	.0150	.0034	0.95	.1250	.0010	3.4
Av.	....	....	....	....	0.29	8.19	2.21	.0086	.0183	.0148	.0035	0.96	.1256	.0010	3.3

Odor, faintly vegetable or none; in May, musty and disagreeable; when heated the odor is generally stronger and frequently musty. — The samples were collected from the brook about 100 feet above the point where it enters Dug Pond. There were heavy rains on the two days preceding August 31.

NATICK.

Microscopical Examination of Water from the South Arm of Pegan Brook near the point where it enters Dug Pond, Natick.

[Number of organisms per cubic centimeter.]

	1891.									
	Feb.	Mar.	Apr.	May.	June.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	5	9	12	3	5	1	2	3	3
Number of sample,	6975	7078	7175	7276	7377	7749	7869	7994	8192	8282
PLANTS.										
Diatomaceæ,	**3**	**0**	**56**	**205**	**7**	**166**	**1**	**0**	**24**	**4**
Asterionella,	2	0	0	36	0	25	0	0	0	0
Cyclotella,	0	0	0	5	0	34	0	0	0	1
Diatoma,	0	0	0	20	pr.	0	0	0	0	1
Melosira,	0	0	2	0	0	71	0	0	0	0
Meridion,	pr.	0	34	2	0	0	pr.	0	pr.	1
Navicula,	0	0	18	18	5	2	1	0	22	pr.
Synedra,	1	0	pr.	124	2	15	0	0	2	1
Tabellaria,	0	0	2	pr.	0	19	0	0	0	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**50**	**0**	**0**	**pr.**	**0**
Clathrocystis,	0	0	0	0	0	38	0	0	0	0
Microcystis,	0	0	0	0	0	12	0	0	pr.	0
Algæ,	**0**	**0**	**87**	**175**	**270**	**36**	**0**	**0**	**pr.**	**0**
Chlorococcus,	0	0	11	9	82	36	0	0	pr.	0
Polyedrium,	0	0	76	0	0	0	0	0	0	0
Raphidium,	0	0	0	4	134	0	0	0	0	0
Scenedesmus,	0	0	0	2	14	pr.	0	0	0	0
Sorastrum,	0	0	0	0	40	0	0	0	0	0
Spirogyra,	0	0	0	160	0	0	0	0	0	0
Fungi,	**0**	**2**	**5**	**0**	**0**	**0**	**63**	**3**	**0**	**14**
Cladothrix,	0	0	0	0	0	0	63	0	0	0
Crenothrix,	0	2	5	0	0	0	0	3	0	14
ANIMALS.										
Infusoria,	**0**	**0**	**14**	**1**	**1**	**7**	**pr.**	**0**	**2**	**0**
Ceratium,	0	0	0	0	0	5	0	0	0	0
Peridinium cases,	0	0	0	0	0	2	0	0	0	0
Synura,	0	0	0	0	0	0	pr.	0	2	0
Trachelomonas,	0	0	14	1	1	0	pr.	0	pr.	0
Vermes. Anurea,	**0**	**0**	**0**	**pr.**	**0**	**2**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**44**	**14**	**342**	**424**	**30**	**28**	**2**	**8**	**4**	**1**
TOTAL,	47	16	504	805	308	289	66	11	30	19

NATICK.

Chemical Examination of Water from Dug Pond, Natick.

[Parts per 100,000.]

Number.	Date of — Collection.	Date of — Examination.	Appearance. — Turbidity.	Appearance. — Sediment.	Appearance. — Color.	Residue on Evaporation. — Total.	Residue on Evaporation. — Loss on Ignition.	Ammonia. — Free.	Ammonia. — Albuminoid. — Total.	Ammonia. — Albuminoid. — Dissolved.	Ammonia. — Albuminoid. — Suspended.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Hardness.
	1891.	1891.													
6864	Jan. 1	Jan. 2	Distinct.	Slight.	0.20	5.80	1.35	.0204	.0226	.0200	.0026	.74	.0480	.0004	2.9
6974	Feb. 3	Feb. 4	Slight.	Cons.	0.20	6.80	1.30	.0200	.0188	.0160	.0028	.74	.0650	.0005	2.5
7079	Mar. 2	Mar. 3	Distinct.	Slight.	0.15	6.00	1.70	.0178	.0164	.0156	.0008	.65	.0620	.0007	2.7
7176	Apr. 6	Apr. 7	V. slight.	V. slight.	0.08	5.90	1.25	.0044	.0100	.0086	.0014	.67	.0400	.0002	2.1
7277	May 4	May 5	Slight.	Slight.	0.10	5.10	1.50	.0000	.0208	.0172	.0036	.67	.0500	.0008	2.5
7376	June 1	June 2	V. slight.	Slight.	0.08	6.05	1.40	.0012	.0172	.0146	.0026	.73	.0500	.0001	2.5
7528	July 2	July 3	Slight.	Slight.	0.02	5.35	1.20	.0010	.0206	.0156	.0050	.62	.0250	.0001	2.5
7750	Aug. 3	Aug. 4	Distinct.	Slight.	0.00	5.25	1.50	.0008	.0244	.0168	.0076	.71	.0150	.0001	1.8
7870	Aug. 31	Sept. 1	Slight.	Slight.	0.10	5.85	1.45	.0004	.0166	.0128	.0038	.72	.0070	.0002	3.2
7995	Oct. 1	Oct. 2	Distinct.	Cons.	0.00	5.65	1.85	.0026	.0272	.0216	.0056	.67	.0070	.0000	2.2
8194	Nov. 2	Nov. 3	Slight.	Slight.	0.10	5.65	1.65	.0098	.0278	.0218	.0060	.69	.0150	.0001	2.1
8283	Dec. 1.	Dec. 2	Slight.	Slight.	0.10	5.15	1.30	.0236	.0268	.0204	.0064	.70	.0070	.0003	2.2
Av.	....	....	....	....	0.09	5.71	1.45	.0085	.0207	.0167	.0040	.69	.0326	.0003	2.4

Odor, generally distinctly vegetable and disagreeable, occasionally none; in May and June, very disagreeable.——The samples were collected from a faucet at the pumping station while pumping, with the exception of No. 7376, which was collected before beginning to pump.

NOTE.—Many dead fish came ashore during the month of June.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	4	5	9	12	2	3	5	1	2	3	3
Number of sample,	6864	6974	7079	7176	7277	7376	7528	7750	7870	7995	8194	8283
PLANTS.												
Diatomaceæ,	**2,266**	**783**	**150**	**1,326**	**966**	**16**	**554**	**2**	**35**	**251**	**423**	**1,241**
Asterionella,	1,798	766	114	0	832	7	16	0	pr.	22	4	77
Cyclotella,	0	0	0	pr.	13	0	472	0	1	1	0	62
Diatoma,	5	0	0	9	16	0	1	0	0	0	0	0
Fragilaria,	0	0	0	0	0	0	0	0	0	0	412	0
Melosira,	426	10	36	286	12	0	0	0	30	128	0	1,064
Stephanodiscus,	26	6	0	5	11	3	53	0	0	pr.	0	0
Synedra,	pr.	0	0	1,026	76	0	pr.	2	0	62	1	31
Tabellaria,	11	1	0	0	6	6	12	0	4	38	5	7
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**99**	**0**	**66**	**244**	**3**	**20**
Aphanocapsa,	0	0	0	0	0	0	0	0	2	5	0	2
Chroöcoccus,	0	0	0	0	0	0	4	0	10	110	0	11
Clathrocystis,	0	0	0	0	0	0	4	0	2	1	0	1
Cœlosphærium,	0	0	0	0	0	0	5	0	pr.	2	1	pr.
Microcystis,	0	0	0	0	0	0	86	0	52	68	2	6
Nostoc,	0	0	0	0	0	0	0	0	0	58	0	0

NATICK.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	4	0	0	2	7	12	21	17	31	102	5	48
Chlorococcus,	4	0	0	2	7	11	21	12	26	100	5	30
Nephrocytium,	0	0	0	0	0	0	0	0	0	0	0	8
Raphidium,	0	0	0	0	0	1	0	3	1	0	0	6
Scenedesmus,	0	0	0	0	pr.	pr.	0	2	pr.	0	0	4
Tetraspora,	0	0	0	0	0	pr.	0	0	4	2	0	0
Fungi. Crenothrix,	1	0	5	1	1	0	0	5	0	0	1	2
ANIMALS.												
Infusoria,	4	3	2	7	516	17	3	pr.	0	1	1	3
Dinobryon,	4	0	pr.	5	512	17	2	0	0	0	0	1
Monas,	0	0	pr.	0	0	0	0	0	0	pr.	pr.	pr.
Peridinium,	pr.	2	0	0	2	0	1	pr.	0	0	0	pr.
Trachelomonas,	pr.	1	2	2	1	0	0	0	0	1	1	2
Crustacea,	0	0	0	0	0	0	pr.	0	0	pr.	0	pr.
Bosmina,	0	0	0	0	0	0	0	0	0	0	0	pr.
Cyclops,	0	0	0	0	0	0	pr.	0	0	pr.	pr.	pr.
Daphnia,	0	0	0	0	0	0	0	0	0	0	0	pr.
Miscellaneous. Zoöglœa,	0	72	380	56	420	31	2	0	182	190	72	29
TOTAL,	2,275	858	537	1,392	1,909	76	679	24	314	788	505	1,343

Chemical Examination of Water from Dug Pond, at the Surface and at the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7764	Aug.10	Aug.11	Distinct.	Slight.	0.02	5.60	1.30	.0004	.0244	.0186	.0058	.73	.0070	.0000	1.9
7765	Aug.10	Aug.11	Decided.	Cons.	0.90	5.60	1.10	.0800	.0242	.0174	.0068	.73	.0150	.0001	2.2

Odor, of No. 7764, none; of No. 7765, distinctly grassy and mouldy. —— The samples were collected from the pond about 200 feet from the pumping station, No. 7764 being collected from near the surface and No. 7765 from near the bottom at a point where the depth was about 30 feet.

Microscopical Examination.

No. 7764. Diatomaceæ, *Asterionella*, 5; *Cyclotella*, 3; *Melosira*, 17; *Navicula*, 1; *Synedra*, 33; *Tabellaria*, 11; Cyanophyceæ, *Aphanocapsa*, 7; *Clathrocystis*, 148; *Cœlosphærium*, 1; *Microcystis*, 138. Algæ, *Chlorococcus*, 51; *Pediastrum*, pr.; *Scenedesmus*, pr. Infusoria, *Ceratium*, pr.; *Monas*, pr.; *Peridinium*, 1. Vermes, *Anurea*, 1. Total, 417.

No. 7765. Diatomaceæ, *Melosira*, 1; *Tabellaria*, 3. Cyanophyceæ, *Chroöcoccus*, 57; *Oscillaria*, 1. Algæ, *Chlorococcus*, 13; *Pediastrum*, pr. Fungi, *Crenothrix*, 44. Miscellaneous, *Zoöglœa*, 1,082. Total, 1,201.

NATICK.

Table showing Heights of Water in Dug Pond at Times when Samples of Water were collected for Analysis.

Note. — Ordinary high-water mark is 18.0 feet.

Date.	Height of Water.	Date.	Height of Water.
1891.		1891.	
Jan. 1,	13.3	July 2,	11.3
Feb. 3,	13.6	Aug. 3,	10.3
Mar. 2,	13.8	Aug. 31,	9.9
Apr. 6,	13.9	Oct. 1,	9.6
May 4,	13.1	Nov. 2,	9.3
June 1,	12.3	Dec. 1,	9.3

Water Supply of Needham.

Chemical Examination of Water from the Well of the Needham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exami-nation.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8245	Nov. 10	Nov. 11	None.	None.	0.0	6.10	.0022	.0022	.72	.1500	.0000	1.7

Odor, none. —— The sample was collected from the well.

Microscopical Examination.

No Organisms.

Water Supply of New Bedford.

Chemical Examination of Water from the Conduit of the New Bedford Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6946	Jan. 26	Jan. 27	V. slight.	None.	1.00	3.70	1.80	.0010	.0172	.0154	.0018	.28	.0300	.0001	0.9
7053	Feb. 24	Feb. 25	V. slight.	V. slight.	1.00	3.60	1.75	.0002	.0118	.0112	.0006	.24	.0200	.0000	1.1
7147	Mar. 26	Mar. 27	V. slight.	Slight.	1.00	3.60	1.45	.0000	.0124	.0100	.0024	.33	.0100	.0000	0.8
7244	Apr. 27	Apr. 28	Slight.	Cons.	1.30	3.50	1.50	.0000	.0168	.0132	.0036	.42	.0070	.0000	0.8
7357	May 25	May 27	V. slight.	Cons.	1.20	4.30	2.00	.0008	.0250	.0226	.0024	.42	.0090	.0000	0.8
7482	June 22	June 25	V. slight.	Slight.	1.30	4.20	2.25	.0014	.0224	.0196	.0028	.45	.0070	.0001	0.8
7729	July 30	July 31	V. slight.	Slight.	0.85	3.50	1.65	.0000	.0270	.0246	.0024	.43	.0100	.0001	0.8
7845	Aug. 24	Aug. 25	V. slight.	Slight.	0.80	3.90	1.65	.0000	.0242	.0218	.0024	.49	.0030	.0001	0.8
7970	Sept. 22	Sept. 23	Slight.	Slight.	0.70	3.55	2.10	.0000	.0222	.0198	.0024	.43	.0050	.0000	0.5
8161	Oct. 22	Oct. 22	V. slight.	V. slight.	0.55	3.90	1.80	.0000	.0184	.0166	.0018	.48	.0050	.0000	0.6
8272	Nov. 23	Nov. 24	V. slight.	Slight.	0.85	4.65	2.00	.0022	.0210	.0172	.0038	.55	.0100	.0000	0.8
8345	Dec. 17	Dec. 18	V. slight.	Slight.	0.90	4.45	1.80	.0006	.0176	.0130	.0046	.57	.0080	.0002	0.9
Av.	....	....	....	....	0.95	3.90	1.81	.0005	.0197	.0171	.0026	.42	.0103	.0000	0.8

Odor, faintly vegetable, frequently none; becomes somewhat stronger on heating. —— The samples were collected from the conduit where it enters the receiving reservoir. This conduit conveys the water from the Acushnet storage reservoir to the city. Water from Little Quittacas Pond was drawn into the storage reservoir during the greater part of the year.

NEW BEDFORD.

Microscopical Examination of Water from the Conduit of the New Bedford Water Works.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	28	28	27	24	31	25	23	23	24	18
Number of sample,	6946	7053	7147	7244	7357	7492	7729	7845	7970	8161	8272	8345
PLANTS.												
Diatomaceæ,	6	3	14	16	5	0	pr.	pr.	0	2	3	1
Asterionella,	1	0	4	0	1	0	0	0	0	0	0	pr.
Melosira,	0	1	0	7	0	0	0	0	0	0	0	0
Synedra,	5	2	10	9	0	0	pr.	pr.	0	pr.	3	1
Tabellaria,	0	0	0	0	4	0	0	pr.	0	2	0	0
Cyanophyceæ. Chroöcoccus,	0	0	0	0	0	0	2	0	17	0	1	0
Algæ,	0	2	0	8	0	9	0	13	187	pr.	0	0
Chlorococcus,	0	2	0	0	0	9	0	13	15	pr.	0	0
Merismopedia,	0	0	0	0	0	0	0	0	172	0	0	0
Zoöspores,	0	0	0	8	0	0	0	0	0	0	0	0
Fungi. Crenothrix,	0	0	0	13	5	1	5	0	0	0	1	1
ANIMALS.												
Infusoria,	pr.	pr.	2	0	pr.	0	3	0	0	0	1	71
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0	70
Monas,	0	0	0	0	0	0	1	0	0	0	1	pr.
Peridinium,	pr.	pr.	2	0	pr.	0	0	0	0	0	0	1
Tintinnidium,	0	0	0	0	0	0	2	0	0	0	0	0
Miscellaneous. Zoöglœa,	4	34	162	128	13	72	242	7	38	9	2	35
TOTAL,	10	39	178	165	23	82	252	20	242	11	8	108

Table showing Heights of Water in Acushnet Reservoir and Little Quittacas Pond in 1891.

NOTE. — Heights are in feet above or below high-water mark. The sign + indicates above high water. The sign — indicates below high water.

DATE.	ACUSHNET RESERVOIR. Height of Water.	LITTLE QUITTACAS POND Height of Water.	DATE.	ACUSHNET RESERVOIR. Height of Water.	LITTLE QUITTACAS POND. Height of Water.
Jan. 1,	0.0	0.0	Sept. 1,	—1.6	—2.8
Feb. 1,	0.0	0.0	Sept. 15,	—1.7	—3.3
Mar. 1,	0.0	0.0	Oct. 1,	—2.3	—3.6
June 1,	—0.4	—1.0	Oct. 7,	—2.5	–
June 15,	—0.6	—1.3*	Oct. 15,	—2.0	—3.4
July 1,	—0.4	—1.7	Nov. 1,	—1.6	—3.3
July 15,	—0.3	—2.1	Nov. 15,	—1.8	—3.5
Aug. 1,	—0.7	—2.5†	Dec. 1,	—1.2	—3.3
Aug. 15,	—1.4	—2.7*	Dec. 15,	—0.9	—3.4

* Connection between Little Quittacas Pond and Acushnet Reservoir opened.

† Connection between Little Quittacas Pond and Acushnet Reservoir closed.

Water Supply of Newton.

Two important additions were made to the Newton Water Works in 1890, one being an extension of the works, for obtaining a supply of ground water, and the other the construction of a covered distributing reservoir.

The extension consists of 174 two and one-half inch tubular wells, from 21 to 130 feet deep, connected with a wooden conduit or gallery 2,952 feet long and four feet square in section, built along the left bank of Charles River. A portion of this conduit, 732 feet in length, replaces an equal length of filter-basin. Its bottom is on a level with that of the filter-basin and water flows from it through the lower portion of the filter-basin, which still remains open, to the pump well at the pumping station.

The covered reservoir is a rectangular chamber, 174 feet long, 125 feet wide and 15½ feet deep. The walls are of rubble masonry coated on the inner side with a layer of Portland cement mortar one-half an inch in thickness. The covering consists of four-inch brick arches supported on lines of brick piers connected by brick lintel arches, the outer edges bearing on the surrounding walls. The piers are 20 inches square and are 11 feet 8 inches apart on centres in one direction and 11 feet 8½ inches apart in the other direction. The bottom of the reservoir is of hard pan, covered with a layer of cement concrete four inches in thickness. The sides of the reservoir are protected by embankments of gravel. The top of the arches is covered with Portland cement concrete to a depth of four inches above their crown; and on the concrete is a layer of loam two feet in thickness; tile drains are laid beneath the loam in grooves, in the concrete, to carry off any surplus rain water. At the centre of each line of arches is located a twenty-four-inch cast-iron ventilator, with openings so arranged as to allow a free circulation of air without admitting direct light.

The gate-chamber is located at one corner of this reservoir, the ultimate design being to have it in the centre of a covered reservoir of four sections, of which the reservoir already built will form the south-east quarter. This chamber is circular and has an inside diameter of 30 feet. Water enters the chamber through a twenty-four-inch force main and rises through a Y branch to a steel distributing tank, 7½ feet in diameter, from which it flows into a twenty four-inch pipe which passes through the walls of the gate-chamber and then downward

NEWTON.

along the bottom of the reservoir to the point of discharge near its centre. Water is drawn from the reservoir near the gate-chamber through a twenty-four-inch pipe having a check-valve upon it to the Y branch of the force-main before mentioned. The walls of the gate-chamber are 7½ feet in thickness and are intended to serve as a foundation for a masonry tower to enclose a stand-pipe to be built when it becomes necessary to furnish greater pressure in the high-service districts.

Chemical Examination of Water from the Filter-Basin and the New System of Tubular Wells of the Newton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.													
6986	Feb. 4	Feb. 5	Slight.	Slight.	0.0	4.25	.0002	.0072	-	-	.31	.0250	.0000	1.8
6987	Feb. 4	Feb. 5	V. slight, clayey.	V. slight.	0.0	4.90	.0000	.0018	-	-	.29	.0250	.0000	2.3

Odor, of No. 6986, none; of No. 6987, faint. No. 6986 was collected from the filter-basin; No. 6987 from the conduit which collects water from the new tubular wells.

Microscopical Examination.

No. 6986. Diatomaceæ, *Amphora*, pr.; *Meridion*, pr.; *Navicula*, 1. Algæ, *Scenedesmus*, 1; *Zoöspores*, 12. Infusoria, *Synura*, 10. Miscellaneous, *Zoöglœa*, 34. Total, 58.

No. 6987. Miscellaneous, *Zoöglœa*, 11.

Chemical Examination of Water from the Charles River, opposite the Filter-basin of the Newton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6985	Feb. 4	Feb. 5	None.	V. slight.	0.60	3.10	1.00	.0008	.0140	.0112	.0028	.18	.0130	.0001	1.1

Odor, very faintly vegetable.——The sample was collected from the river opposite the upper end of the old filter-basin. The low residue on evaporation and chlorine of this sample are doubtless due to dilution, as the flow of the stream was very large for a month previous to the date of collecting the sample.

Microscopical Examination.

Diatomaceæ, *Melosira*, 1; *Synedra*, 1. Infusoria, *Dinobryon*, pr.; *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 9. Total, 12.

NEWTON.

Chemical Examination of Water from the Underdrain of the Hyde Brook Division of the Newton Sewerage System.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.													
8330	-	Dec. 15	Distinct, clayey.	Heavy.	0.0	26.05	.0200	.0036	.0026	.0010	3.15	1.5000	.0050	10.7

Odor, faintly musty, becoming offensive on standing.—— The sample was collected from the underdrain at its outlet, before any sewage was admitted to the sewers. The analysis therefore shows the pollution of the ground water of this portion of the city by the leachings from cesspools and privies.

Microscopical Examination.

Fungi, *Beggiatoa*, 98; *Molds*, 38. Total, 136.

Water Supply of Northampton.

Chemical Examination of Water from the Upper and Lower Storage Reservoirs of the Northampton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8176	Oct. 29	Oct. 30	V. slight.	V. slight.	0.40	5.10	1.30	.0010	.0090	.0072	.0018	.12	.0070	.0000	2.2
8177	Oct. 29	Oct. 30	Slight.	Slight.	0.40	5.15	1.35	.0002	.0090	.0076	.0014	.13	.0050	.0000	1.9

Odor, none.——No. 8176 was collected from the upper reservoir, and No. 8177 from the lower reservoir.

Microscopical Examination.

No. 8176. Algæ, *Chlorococcus*, 6; *Dictyosphærium*, 20; *Scenedesmus*, pr. Fungi, *Crenothrix*, 94; *Molds*, 1. Miscellaneous, *Zoöglœa*, 31. Total, 152.

No. 8177. Diatomaceæ, *Navicula*, 3; *Tabellaria*, 1. Fungi, *Crenothrix*, 59; *Molds*, 1. Miscellaneous, *Zoöglœa*, 2. Total, 66.

NORTHBOROUGH.

WATER SUPPLY OF NORTHBOROUGH.

In 1889, in order to increase the storage capacity of the works, the town took possession of a mill privilege on Cold Harbor Brook, about a mile above the storage reservoir from which the supply for the town is drawn. The area of the mill pond is about eight acres and its maximum depth is nine feet. The bottom is said to be muddy in the middle and sandy near the shores.

NORTH BROOKFIELD.

Chemical Examination of Water from Ponds and Streams in North Brookfield collected during an Investigation with reference to obtaining a Water Supply for the Town.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7200	Apr. 10	Apr. 11	V. slight.	Slight, earthy.	0.28	2.75	1.00	.0000	.0114	.0102	.0012	.11	.0030	.0000	0.8
7201	Apr. 10	Apr. 11	V. slight.	Cons., earthy.	0.28	3.60	1.10	.0030	.0152	.0134	.0018	.19	.0030	.0001	1.1
7202	Apr. 10	Apr. 11	V. slight.	Cons.	0.20	3.30	1.65	.0000	.0154	.0134	.0020	.11	.0030	.0000	0.6
7203	Apr. 10	Apr. 11	V. slight.	Cons.	0.28	5.85	1.00	.0000	.0202	.0144	.0058	.12	.0050	.0000	1.4
7349	May 25	May 26	V. slight.	Cons.	2.30	4.75	3.05	.0010	.0330	.0262	.0068	.05	.0050	.0000	0.8
7350	May 25	May 26	V. slight.	Slight.	0.00	4.05	0.85	.0032	.0120	.0104	.0016	.22	.0220	.0001	0.8
7351	May 25	May 26	V. slight.	Cons., earthy.	0.05	3.40	1.40	.0008	.0122	.0098	.0024	.12	.0100	.0000	0.8
7352	May 25	May 26	V. slight.	V. slight.	0.60	3.70	1.10	.0000	.0160	-	-	.16	.0100	.0000	0.8
7519	July 1	July 2	Slight.	Cons.	0.70	3.00	1.65	.0008	.0330	.0268	.0062	.07	.0030	.0001	0.5
7520	July 1	July 2	Slight.	Cons.	0.75	3.30	1.65	.0008	.0346	.0256	.0090	.07	.0030	.0001	0.6

Odor, of Nos. 7200, 7201 and 7351, none; of Nos. 7202 and 7203, distinctly vegetable; and of the others, faintly vegetable; the odors were not changed by heating.——Nos. 7202 and 7520 were collected from Doane's Pond at its outlet. No. 7200 was from Batchelder's Brook, a tributary of Doane's Pond from the north. No. 7201 was from a brook which flows into Doane's Pond from the south. Nos. 7203 and 7519 were collected from Horse Pond at its outlet. This pond was very low when No. 7519 was collected. It is situated about half a mile north of Doane's Pond and water from it flows through a brook into Doane's Pond. Nos. 7351 and 7352 were collected from Coy's Brook, which lies about three-fourths of a mile west of the village of North Brookfield, and flows in a southerly direction toward the Quaboag River. No. 7351 was from the brook above the entrance of Cumming's Brook and No. 7352 was from the brook below both Cumming's and Bliss' brooks. No. 7350 was from Cumming's Brook, a tributary of Coy's Brook from the east. No. 7349 was from Bliss' Brook, a tributary of Coy's Brook from the west.

NORTH BROOKFIELD.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891.									
	April.	April.	April.	April.	May.	May.	May.	May.	July.	July.
Day of examination,	13	13	13	13	26	26	27	27	2	2
Number of sample,	7200	7201	7202	7203	7349	7350	7351	7352	7519	7520
PLANTS.										
Diatomaceæ,	11	67	24	11	10	8	28	54	pr.	pr.
Asterionella,	0	0	0	4	0	0	pr.	2	pr.	0
Diatoma,	0	8	0	3	0	8	1	2	0	0
Meridion,	5	58	0	pr.	pr.	0	0	0	0	0
Navicula,	2	1	3	pr.	3	pr.	18	16	0	0
Stephanodiscus,	0	0	20	0	0	0	pr.	0	0	0
Synedra,	2	0	pr.	2	1	0	6	34	0	pr.
Tabellaria,	2	0	1	2	6	0	3	pr.	0	pr.
Cyanophyceæ. Chroöcoccus,	0	0	0	0	0	0	0	0	0	9
Algæ,	0	0	1	pr.	15	29	2	10	30	20
Chlorococcus,	0	0	0	0	0	0	0	0	29	0
Closterium,	0	0	1	pr.	0	2	1	4	1	0
Cosmarium,	0	0	pr.	0	15	22	0	4	0	0
Ulothrix,	0	0	0	0	0	5	1	2	0	0
Zoöspores,	0	0	0	0	0	0	0	0	0	20
Fungi. Crenothrix,	5	32	2	5	0	2	0	3	111	4
ANIMALS.										
Rhizopoda,	0	0	3	1	0	0	0	0	0	12
Actinophrys,	0	0	0	0	0	0	0	0	0	12
Difflugia,	0	0	3	1	0	0	0	0	0	0
Infusoria,	0	0	3	68	1	0	0	0	0	102
Dinobryon,	0	0	0	0	0	0	0	0	0	95
Peridinium,	0	0	3	68	pr.	0	0	0	0	pr.
Trachelomonas,	0	0	0	0	1	0	0	0	0	1
Uroglena volvox,	0	0	0	0	0	0	0	0	0	6
Vermes. Synchæta,	0	0	0	2	0	0	0	0	0	0
Crustacea,	0	0	pr.	pr.	0	0	0	0	0	0
Bosmina,	0	0	pr.	pr.	0	0	0	0	0	0
Cyclops,	0	0	pr.	pr.	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	13	716	162	256	100	132	72	188	0	376
TOTAL,	29	815	195	343	126	171	102	255	141	523

NORWOOD.

WATER SUPPLY OF NORWOOD.

Chemical Examination of Water from Buckmaster Pond, in Dedham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6939	Jan. 22	Jan. 24	Slight.	Slight.	0.03	2.00	0.70	.0014	.0088	.0078	.0010	.24	.0200	.0000	0.9
7032*	Feb. 18	Feb. 20	V. slight.	V. slight.	0.02	1.85	0.45	.0030	.0066	.0058	.0008	.16	.0100	.0001	-
7066	Mar. 2	Mar. 2	Slight.	V. slight.	0.05	2.45	1.05	.0038	.0176	.0170	.0006	.26	.0090	.0003	1.1
7137	Mar. 19	Mar. 20	V. slight.	V. slight.	0.10	2.55	0.70	.0024	.0076	.0068	.0008	.28	.0600	.0001	0.6
7243	Apr. 27	Apr. 28	Slight.	V. slight.	0.10	2.25	0.95	.0000	.0158	.0136	.0022	.26	.0150	.0000	0.8
7334	May 20	May 20	Slight.	V. slight.	0.05	2.50	1.30	.0004	.0176	.0164	.0012	.22	.0070	.0000	0.6
7468	June 16	June 19	Slight.	Slight.	0.10	2.50	0.60	.0010	.0168	.0142	.0026	.22	.0030	.0000	0.8
7612	July 23	July 25	Slight.	Slight.	0.08	2.05	1.15	.0000	.0176	.0156	.0020	.22	.0020	.0000	-
7843	Aug. 20	Aug. 22	Slight.	Slight.	0.05	2.80	1.15	.0000	.0168	.0144	.0024	.29	.0020	.0000	0.6
7911	Sept. 10	Sept. 11	Distinct.	Slight.	0.08	2.50	1.00	.0000	.0248	.0190	.0058	.30	.0050	.0000	0.5
8148	Oct. 20	Oct. 21	V. slight.	Slight.	0.02	2.60	1.25	.0000	.0264	.0220	.0044	.26	.0030	.0000	0.3
8252	Nov. 10	Nov. 11	V. slight.	Slight.	0.04	2.50	1.00	.0022	.0234	.0186	.0048	.32	.0050	.0000	0.6
8348	Dec. 17	Dec. 18	Slight.	Cons.	0.07	3.75	1.35	.0046	.0162	.0114	.0048	.29	.0090	.0001	0.3
Av.	....	....	....	....	0.06	2.48	0.97	.0014	.0166	.0140	.0026	.26	.0075	.0000	0.7

Odor, vegetable or none, rarely unpleasant.——The samples were collected from the pond, near the surface, opposite the pumping station.

* This sample probably contained melted ice or snow.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	24	20	5	21	28	21	19	25	22	11	21	12	18
Number of sample,	6939	7032	7066	7137	7243	7334	7468	7612	7843	7911	8148	8252	8348
PLANTS.													
Diatomaceæ,	2	1	11	0	7	2	16	0	1	8	6	90	32
Asterionella,	0	0	0	0	0	0	0	0	0	8	0	45	10
Cyclotella,	0	0	0	0	0	0	0	0	0	1	2	14	9
Melosira,	2	0	2	0	0	1	0	0	0	1	2	19	2
Navicula,	0	0	0	0	1	pr	0	0	1	2	1	2	5
Nitzschia,	0	0	0	0	0	0	15	0	0	0	0	0	0
Synedra,	0	1	9	0	5	1	0	0	0	2	0	10	6
Tabellaria,	0	0	0	0	1	pr.	1	0	0	0	1	0	0

NORWOOD.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.													
Cyanophyceæ,	0	0	0	0	60	10	0	pr.	6	178	0	178	3
Chroöcoccus,	0	0	0	0	60	10	0	0	0	100	0	28	0
Microcystis,	0	0	0	0	0	0	0	pr.	6	78	0	150	3
Algæ,	0	8	2	0	0	22	15	392	35	2	0	17	pr.
Chlorococcus,	0	8	2	0	0	22	15	392	35	0	0	7	pr.
Raphidium,	0	0	0	0	0	0	0	0	0	2	0	10	0
Fungi. Crenothrix,	0	0	0	0	0	0	1	0	0	0	9	0	0
ANIMALS.													
Rhizopoda. Actinophrys,	0	0	0	0	2	5	0	0	0	pr.	0	2	0
Infusoria,	5	60	3	0	1	pr.	7	6	3	9	0	pr.	0
Dinobryon cases,	2	60	3	0	0	0	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	2	0	0	0
Peridinium,	1	pr.	pr.	0	1	0	pr.	6	1	4	0	0	0
Trachelomonas,	0	0	pr.	0	0	pr.	0	0	0	3	0	pr.	0
Uroglena volvox,	2	0	0	0	0	0	0	0	0	0	0	0	0
Vorticella,	0	0	0	0	0	0	7	0	2	pr.	0	0	0
Vermes,	2	0	2	0	0	pr.	0	0	0	0	0	pr.	pr.
Anurea,	2	0	1	0	0	pr.	0	0	0	0	0	0	0
Rotatorian ova,	pr.	0	1	0	0	0	0	0	0	0	0	pr.	pr.
Crustacea. Cyclops,	0	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	1	42	322	8	20	30	4	99	6	180	1	114	42
TOTAL,	10	111	340	8	90	69	43	497	51	378	16	396	77

Table of Heights of Water in Buckmaster Pond, at Times when Samples of Water were collected for Analysis.

NOTE. — Heights are in feet above or below the crest of the dam. The sign + indicates above the crest; the sign — below the crest.

DATE.	Height of Water.	DATE.	Height of Water.
1891.	Feet.	1891.	Feet.
Jan. 22,	+0.5	July 23,	—2.7
Feb. 18,	+0.3	Aug. 20,	—3.7
Mar. 2,	+0.5	Sept. 10,	—4.0
Mar. 19,	+0.5	Oct. 20,	—5.0
Apr. 27,	0.0	Nov. 10,	—5.5
May 20,	—0.7	Dec. 17,	—4.5
June 16,	1.4		

ORANGE.

ORANGE.

Chemical Examination of Water from North Pond, Hastings Pond and Coolidge Brook, in Orange, collected during an Investigation with reference to obtaining a new Water Supply for the Town.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7009	Feb. 12	Feb. 13	None.	V. slight.	0.80	3.35	1.45	.0026	.0138	.0124	.0014	.06	.0060	.0001	0.9
7010	Feb. 12	Feb. 13	None.	V. slight.	0.10	2.55	0.70	.0000	.0026	.0010	.0016	.08	0070	.0000	0.5
7011	Feb. 12	Feb. 13	None.	V. slight.	1.00	4.70	2.10	.0146	.0166	.0152	.0014	.07	.0090	.0001	2.1

Odor, none, becoming vegetable on heating.——Sample No. 7009 was collected from North Pond near its outlet. The pond is about 1½ miles from the village of Orange in a south-westerly direction. No. 7010 was collected from Coolidge Brook, a stream which lies near North Pond, and could be diverted into it. No. 7011 was collected from Hastings Pond at its outlet. This pond is about 6 miles north of the village of Orange.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. February.	1891. February.	1891. February.
Day of examination,	14	14	14
Number of sample,	7009	7010	7011
PLANTS.			
Diatomaceæ,	7	7	1
Nitzschia,	5	1	0
Tabellaria,	2	6	1
Fungi. Crenothrix,	0	0	2
ANIMALS.			
Infusoria,	pr.	0	pr.
Peridinium,	pr.	0	pr.
Synura,	0	0	pr.
Vermes. Anuræa,	0	0	pr.
Crustacea. Cyclops,	0	pr.	0
Miscellaneous. Zoöglœa,	0	12	1
TOTAL,	7	19	4

Water Supply of Peabody.

Chemical Examination of Water from Spring Pond, Peabody.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6969	Feb. 2	Feb. 3	Slight.	V. slight.	0.00	3.10	1.20	.0008	.0118	.0090	.0028	.54	.0070	.0001	1.1
6991	Feb. 6	Feb. 9	V. slight.	None.	0.02	3.35	0.80	.0006	.0088	.0072	.0016	.50	.0060	.0000	1.4
7104*	Mar. 10	Mar. 11	V. slight.	None.	0.00	1.80	0.60	.0028	.0080	.0074	.0006	.34	.0150	.0001	0.3
7297	May 11	May 12	Slight.	V. slight.	0.02	4.25	0.95	.0000	.0158	.0124	.0034	.57	.0030	.0000	1.7
7418	June 8	June 10	V. slight.	V. slight.	0.01	3.65	0.85	.0004	.0138	.0090	.0048	.60	.0030	.0000	0.9
7561	July 14	July 15	Slight.	Slight.	0.00	3.60	0.80	.0020	.0136	.0102	.0034	.55	.0020	.0001	1.1
7803	Aug. 13	Aug. 14	Slight.	Slight.	0.02	3.55	1.20	.0000	.0106	.0092	.0014	.58	.0000	.0000	1.1
7916	Sept. 9	Sept. 11	V. slight.	Slight.	0.00	3.45	1.00	.0000	.0122	.0090	.0032	.44	.0070	.0001	1.3
8018	Oct. 5	Oct. 7	V. slight.	V. slight.	0.00	4.65	1.45	.0012	.0140	.0120	.0020	.57	.0070	.0000	1.6
8227	Nov. 5	Nov. 6	None.	V. slight.	0.02	3.65	0.70	.0000	.0104	.0090	.0014	.60	.0020	.0000	1.3
Av.	....	....	....	....	0.01	3.69	0.99	.0006	.0123	.0097	.0027	.55	.0041	.0000	1.3

Odor, generally none, occasionally vegetable, rarely mouldy.——The samples were collected from the pond.

* This sample probably contained water derived from melting snow and ice, and is therefore omitted from the average.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Feb.	Feb.	Mar.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Day of examination,	4	11	11	13	10	15	14	11	7	7
Number of sample,	6969	6991	7104	7297	7418	7561	7803	7916	8018	8227
PLANTS.										
Diatomaceæ,	**0**	**pr.**	**0**	**96**	**283**	**79**	**7**	**4**	**2**	**21**
Asterionella,	0	0	0	36	13	7	0	0	0	0
Cyclotella,	0	0	0	0	0	58	1	0	0	5
Stephanodiscus,	0	0	0	3	172	0	0	pr.	pr	0
Synedra,	0	0	0	1	0	4	0	1	pr.	3
Tabellaria,	0	pr.	0	56	98	10	6	3	2	13
Cyanophyceæ,	**0**	**0**	**0**	**56**	**0**	**1**	**2**	**60**	**30**	**pr.**
Microcystis,	0	0	0	0	0	0	2	60	30	pr.
Nostoc,	0	0	0	56	0	1	0	pr.	0	0
Algæ,	**0**	**0**	**0**	**0**	**4**	**2**	**72**	**21**	**0**	**5**
Chlorococcus,	0	0	0	0	4	0	70	8	0	2
Eudorina,	0	0	0	0	0	0	0	13	0	0
Raphidium,	0	0	0	0	0	2	2	0	0	3

PEABODY.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.									
	Feb.	Feb	Mar	May.	June.	July.	Aug	Sept.	Oct.	Nov.
ANIMALS.										
Rhizopoda. Actinophrys,	0	0	0	0	0	0	1	0	0	8
Infusoria,	222	58	16	19	pr.	0	2	4	2	5
Dinobryon,	222	58	16	0	0	0	0	4	0	0
Peridinium,	0	0	0	0	pr.	0	2	0	0	1
Peridinium cases,	0	0	0	0	0	0	0	0	0	1
Trachelomonas,	0	0	0	0	0	0	0	0	2	3
Vorticella,	0	0	0	19	0	0	0	0	0	0
Crustacea. Cyclops,	0	0	0	pr.	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	12	0	7	6	2	2	5	76	106	32
TOTAL,	234	58	23	177	289	84	89	165	140	71

WATER SUPPLY OF PITTSFIELD.

The town of Pittsfield became a city in 1891, and the fire district, which formerly owned the water works, was abolished, so that the works are now owned by the city. Owing to the dry weather in 1891 the supply was nearly exhausted, and a temporary pumping station was constructed to take water from Sackett Brook, a short distance below its junction with Ashley Brook, and pump it into the main pipe leading to the city. The total watershed above the pumping station, as measured from the State map, is 8.98 square miles.

Chemical Examination of Water from Streams in Pittsfield, Dalton and Lenox, made during an investigation with reference to obtaining an additional Supply of Water for Pittsfield.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.	
	1891.														
8354	Dec. 18	Dec. 19	None.	V. slight.	0.00	6.40	1.65	.0000	.0030	.0022	.0008	.06	.0250	.0000	4.6
8355	Dec. 18	Dec. 19	V. slight	Slight.	0.02	9.30	-	.0000	.0022	.0012	.0010	.08	.0180	.0000	8.4
8356	Dec. 18	Dec. 19	V. slight.	None.	0.02	12.75	-	.0000	.0014	.0012	.0002	.08	.0200	.0000	12.1

Odor, none. —— No. 8354 was collected from Mill Brook, which is the first brook that flows into the Housatonic River from the east, south of New Lenox. No. 8355 was collected from Hathaway Brook, which lies between Ashley and Sackett brooks and flows into the latter. No. 8356 was collected from Sackett Brook a short distance below its confluence with Ashley and near the temporary pumping station of the Pittsfield Water Works.

PITTSFIELD.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891.		
	December.	December.	December.
Day of examination,	19	19	19
Number of sample,	8354	8355	8356
PLANTS.			
Diatomaceæ,	0	5	3
Meridion,	0	4	0
Tabellaria,	0	1	3
ANIMALS.			
Infusoria. Peridinium cases,	0	1	0
Miscellaneous. Zoöglœa,	22	16	0
TOTAL,	22	22	3

Chemical Examination of Water from Onota Lake, Pittsfield.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8352	Dec. 18	Dec. 19	V. slight.	V. slight.	0.00	7.85	1.00	.0000	.0110	.0096	.0014	.07	.0020	.0001	6.6
8353	Dec. 18	Dec. 19	Slight.	Slight.	0.03	7.40	0.95	.0046	.0092	.0054	.0038	.06	.0090	.0002	5.7

Odor of No. 8352, none; of No. 8353, faintly vegetable. —— No. 8352 was collected from the southerly division of the lake near its easterly shore, about one-third the length of the lake from its northerly end. No. 8353 was collected from the northerly division at its outlet.

NOTE. — The samples were collected during an investigation for an additional water supply for Pittsfield.

Microscopical Examination.

No. 8352. Diatomaceæ, *Asterionella*, 4; *Cyclotella*, 9; *Diatoma*, 1; *Fragilaria*, 9; *Navicula*, 1; *Synedra*, 7. Algæ, *Chlorococcus*, 2. Infusoria, *Dinobryon*, 2; *Peridinium*, 2; *Trachelomonas*, 1. Vermes, *Rotatorian ova*, 1. Crustacea, *Cyclops*, pr. Miscellaneous, *Zoöglœa*, 21. Total, 60.

No. 8353. Diatomaceæ, *Cyclotella*, 4; *Melosira*, 1; *Navicula*, 4; *Synedra*, 20; *Tabellaria*, 1. Algæ, *Chlorococcus*, 1. Infusoria, *Dinobryon*, 1; *Glenodinium*, 1. Miscellaneous, *Zoöglœa*, 47. Total, 80.

QUINCY.

WATER SUPPLY OF QUINCY. — QUINCY WATER COMPANY.

Chemical Examination of Water from Town Brook, just above the Storage Reservoir of the Quincy Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6949	Jan. 26	Jan. 27	V. slight.	Slight.	0.30	3.30	1.00	.0002	.0116	.0080	.0036	.39	.0120	.0001	0.8
7054	Feb. 24	Feb. 25	V. slight.	Slight.	0.30	3.00	1.05	.0000	.0052	.0048	.0004	.37	.0180	.0000	0.6
7140	Mar. 23	Mar. 24	Slight, green.	Slight.	0.25	2.65	1.10	.0002	.0100	.0068	.0032	.45	.0050	.0002	0.8
7252	Apr. 27	Apr. 29	V. slight.	Slight.	0.80	3.60	0.95	.0000	.0176	.0158	.0018	.46	.0070	.0000	0.8
7347	May 25	May 26	Slight.	Cons.	0.75	3.90	1.40	.0006	.0176	.0156	.0020	.42	.0100	.0000	0.8
7479	June 22	June 23	Slight.	Cons.	1.50	5.65	2.85	.0024	.0362	.0306	.0056	.51	.0100	.0001	0.8
7735	July 30	July 31	V. slight.	Slight.	0.60	4.35	0.75	.0010	.0150	.0134	.0016	.44	.0150	.0000	0.5
7855	Aug. 24	Aug. 25	Slight.	Slight.	0.80	4.60	1.35	.0006	.0176	.0148	.0028	.53	.0100	.0001	0.6
7964	Sept. 21	Sept. 22	V. slight.	Cons.	0.60	4.65	1.65	.0000	.0118	.0100	.0018	.54	.0150	.0000	0.8
8145	Oct. 20	Oct. 21	V. slight.	Slight.	1.00	5.10	2.00	.0000	.0184	.0158	.0026	.58	.0150	.0001	0.8
8275	Nov. 23	Nov 24	V. slight.	V. slight.	0.85	4.30	1.75	.0002	.0130	.0114	.0016	.61	.0090	.0000	0.8
8350	Dec. 17	Dec. 19	V. slight.	Slight.	0.85	5.50	2.20	.0000	.0138	.0114	.0024	.60	.0090	.0001	0.6
Av.	....	... .	....	....	0.72	4.22	1.50	.0004	.0156	.0132	.0024	.49	.0112	.0001	0.7

Odor, distinctly vegetable.——The samples were collected from the brook above the storage reservoir. There was a heavy rain during the night previous to the collection of No. 7479.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	24	29	26	23	31	25	22	21	24	19
Number of sample,	6949	7054	7140	7252	7347	7479	7735	7855	7964	8145	8275	8350
PLANTS.												
Diatomaceæ,	37	114	62	50	17	13	3	7	0	5	3	6
Diatoma,	0	0	52	44	9	6	pr.	0	0	0	0	pr.
Melosira,	0	4	0	0	1	0	0	6	0	0	0	0
Meridion,	20	76	5	0	1	0	1	0	0	0	2	0
Navicula,	0	1	0	2	pr.	1	1	0	0	pr.	pr.	0
Striatella,	0	6	0	0	0	0	0	0	0	0	0	0
Synedra,	16	26	3	2	pr.	0	0	0	0	5	1	2
Tabellaria,	1	1	2	2	6	6	1	1	0	0	pr.	4
Algæ,	0	1	37	1	0	0	0	pr.	0	0	0	pr.
Chlorococcus,	0	1	7	0	0	0	0	pr.	0	0	0	pr.
Tetraspora,	0	0	10	0	0	0	0	0	0	0	0	0
Zoöspores,	0	0	20	1	0	0	0	0	0	0	0	pr.
Fungi. Crenothrix,	0	pr.	6	4	5	13	1	1	8	27	6	pr.

QUINCY.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda. Actinophrys, . .	4	1	0	0	0	0	0	0	0	0	0	0
Infusoria, ...	7	pr.	0	0	2	1	1	3	pr.	0	0	pr.
Dinobryon, ...	7	0	0	0	0	0	0	0	0	0	0	0
Monas, ...	0	pr.	0	0	2	1	1	0	pr.	0	0	pr.
Peridinium, ...	0	0	0	0	pr.	0	0	1	0	0	0	0
Trachelomonas, ...	0	0	0	0	0	pr.	0	2	pr.	0	0	0
Miscellaneous. Zoöglœa, . . .	10	16	2	22	11	146	18	41	35	26	0	1
TOTAL, ...	58	132	101	77	35	173	23	52	43	58	3	7

Chemical Examination of Water from the Storage Reservoir of the Quincy Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6950	Jan. 26	Jan. 27	Slight.	Slight, green.	0.15	2.45	1.35	.0006	.0202	.0088	.0114	.23	.0150	.0000	0.5
7055	Feb. 24	Feb. 25	V. slight.	V. slight.	0.30	2.95	0.85	.0000	.0106	.0066	.0040	.39	.0200	.0000	0.6
7141	Mar. 23	Mar. 24	Slight.	Slight.	0.20	2.95	0.60	.0000	.0126	.0066	.0060	.42	.0100	.0002	0.8
7253	Apr. 27	Apr. 29	Slight.	Cons.	0.30	3.40	1.45	.0000	.0158	.0124	.0034	.52	.0090	.0000	0.8
7348	May 25	May 26	Distinct.	Cons.	0.50	3.30	1.30	.0018	.0304	.0192	.0112	.47	.0120	.0001	0.6
7480	June 22	June 23	Distinct.	Cons.	0.80	4.10	2.05	.0010	.0258	.0190	.0068	.55	.0030	.0000	0.6
7736	July 30	July 31	V. slight.	Slight.	0.80	4.10	1.25	.0054	.0342	.0262	.0080	.54	.0100	.0000	0.6
7854	Aug. 24	Aug. 25	Decided, green.	Slight.	0.90	3.95	1.90	.0000	.0488	.0286	.0202	.58	.0000	.0001	0.6
7965	Sept. 21	Sept. 22	Decided.	Cons.	1.20	4.80	2.50	.0000	.0482	.0256	.0226	.55	.0070	.0000	1.1
8144	Oct. 20	Oct. 21	Distinct, green.	Cons., green.	1.20	4.75	1.85	.0050	.0346	.0244	.0102	.59	.0050	.0000	0.8
8276	Nov. 23	Nov. 24	Slight.	Slight.	1.10	6.30	2.15	.0098	.0256	.0206	.0050	.61	.0090	.0001	0.5
8361	Dec. 19	Dec. 19	Slight.	V. slight.	0.90	4.55	2.00	.0090	.0222	.0156	.0066	.61	.0200	.0001	0.8
Av.	....	....	....	....	0.70	3.97	1.60	.0027	.0274	.0178	.0096	.50	.0100	.0000	0.7

Odor, generally vegetable, sometimes unpleasant, becoming stronger on heating. —— The samples were collected from the reservoir near the surface at the dam. From the first of January to the end of March, water flowed over the rollway and was also wasted from the bottom. The reservoir remained full until the end of April, and then went down gradually until about September 21, when the surface was about four feet below high-water mark. From this time the reservoir gradually rose and was about half a foot below high-water mark on December 19, when the last sample of water was collected.

QUINCY.

Microscopical Examination of Water from the Storage Reservoir of the Quincy Water Company.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept	Oct	Nov.	Dec.
Day of examination,	27	26	24	29	26	23	31	25	22	21	24	22
Number of sample,	6950	7055	7141	7253	7348	7480	7736	7854	7965	8144	8276	8361
PLANTS.												
Diatomaceæ,	**1**	**68**	**15**	**333**	**93**	**5**	**7**	**0**	**151**	**24**	**38**	**20**
Asterionella,	0	4	13	240	92	3	0	0	132	24	22	12
Cyclotella,	0	0	0	0	0	0	0	0	19	0	pr.	4
Diatoma,	0	0	0	36	1	0	0	0	0	0	8	0
Meridion,	0	28	0	0	0	0	0	0	0	0	pr.	0
Synedra,	1	36	2	54	0	0	6	0	0	0	8	0
Tabellaria,	0	0	pr.	3	0	2	1	0	0	0	pr.	4
Cyanophyceæ,	**0**	**0**	**0**	**8**	**0**	**0**	**3**	**1,008**	**232**	**28**	**4**	**0**
Chroöcoccus,	0	0	0	8	0	0	0	0	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	3	1,008	232	28	4	0
Algæ,	**0**	**22**	**137**	**60**	**215**	**24**	**52**	**2**	**1**	**47**	**5**	**0**
Chlorococcus,	0	0	20	10	13	24	52	2	0	0	5	0
Closterium,	0	22	11	pr.	0	0	0	0	0	0	pr.	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	47	0	0
Pediastrum,	0	0	0	1	5	0	pr.	0	0	0	0	0
Scenedesmus,	0	0	0	0	186	0	0	0	1	0	pr.	0
Sorastrum,	0	0	0	1	11	0	0	0	0	0	0	0
Zoöspores,	0	0	106	48	0	pr.	0	0	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**2**	**3**	**0**	**pr.**	**pr.**	**0**	**3**	**0**	**0**	**pr.**
ANIMALS.												
Rhizopoda,	**0**	**1**	**0**	**0**	**6**	**25**	**68**	**0**	**0**	**0**	**0**	**0**
Actinophrys,	0	1	0	0	0	25	68	0	0	0	0	0
Difflugia,	0	0	0	0	6	0	0	0	0	0	0	0
Infusoria,	**134**	**114**	**338**	**27**	**4**	**pr.**	**273**	**0**	**20**	**2**	**1**	**2**
Dinobryon,	4	24	272	5	0	0	7	0	0	0	0	0
Dinobryon cases,	0	0	0	0	0	0	250	0	0	1	0	0
Monas,	0	48	0	0	0	pr.	2	0	4	0	0	pr.
Peridinium,	130	42	66	1	2	0	4	0	0	0	0	1
Synura,	0	0	0	0	0	0	0	0	0	1	1	0
Tintinnidium,	0	0	0	0	2	pr.	0	0	1	0	0	0
Trachelomonas,	0	0	pr.	21	0	pr.	10	0	15	pr.	0	1
Vermes,	**0**	**2**	**0**	**pr.**	**6**	**pr.**	**0**	**0**	**3**	**0**	**0**	**1**
Anuræa,	0	0	0	pr.	6	pr.	0	0	1	0	0	0
Rotatorian ova,	0	2	0	0	0	0	0	0	0	0	0	1
Triarthra,	0	0	0	pr.	0	0	0	0	2	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**0**	**0**
Cyclops,	0	0	0	0	pr.	pr.	pr.	0	pr.	pr.	0	0
Daphnia,	0	0	0	0	0	pr.	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**242**	**108**	**92**	**240**	**6**	**60**	**188**	**0**	**798**	**3**	**92**	**38**
TOTAL,	377	315	584	671	330	114	571	1,010	1,206	104	140	61

Water Supply of Reading.

Description of Works. — Population in 1890, 4,088. The works are owned by the town. Water was introduced in February, 1891. The source of supply is a filter-gallery located in the northerly part of the town on the right bank of the Ipswich River, about three hundred feet above the dam at Mill Street. The gallery is located beneath a meadow which is subject to flowage to a depth of five feet during the six months from October 12 to April 12. The bottom of the filter-gallery is twenty-two feet below the level of the meadow and is built in two connecting sections, one about 75 feet long, parallel with the river, and the other about 175 feet long, perpendicular to it. The gallery is built with loose stone side walls and is covered over with flat stones laid in cement mortar. It is 3½ feet wide and 4 feet high inside. The dam is an ancient one, and it is probable that the quality of the water is affected to some extent by the fact that the meadow has always acted to a greater or less extent as a filter every time it has been flowed, on account of the difference in the water level above and below the dam.

A twelve-inch suction pipe conveys the water from the filter-gallery to the pumping station, which is located below the dam. Another twelve-inch pipe extends from the pumping station to the Ipswich River, for use in cases of emergency. Water is pumped to the town and to an iron tank, 30 feet in diameter and 100 feet high, which is covered to exclude the light. Distributing mains are of cast iron; service pipes are of wrought iron lined with cement.

READING.

Chemical Examination of Water from the Filter-gallery of the Reading Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7247	Apr. 27	Apr. 29	Decided.	Heavy.	0.00	14.40	-	.0000	.0022	.0014	.0008	.32	.2000	.0000	6.6
7366	May 27	May 27	Decided.	Heavy.	0.00	11.50	-	.0004	.0042	.0020	.0022	.35	.0150	.0001	5.1
7543	July 6	July 9	Decided.	Heavy.	0.00	14.20	-	.0018	.0046	.0022	.0024	.40	.0150	.0002	5.3
7739	July 30	Aug. 1	Distinct.	Heavy.	0.15	11.30	-	.0002	.0068	-	-	.43	.0090	.0000	3.9
7782	Aug. 10	Aug. 12	Distinct, milky.	Heavy.	0.40	9.35	-	.0022	.0056	.0034	.0022	.41	.0050	.0001	3.8
7826	Aug. 19	Aug. 19	Slight, milky.	Slight.	0.20	10.40	-	.0018	.0034	-	-	.42	.0000	.0000	3.1
7945	Sept. 16	Sept. 17	Distinct, milky.	Slight, floc.	0.30	10.00	-	.0004	.0030	-	-	.46	.0100	.0001	3.3
8142	Oct. 19	Oct. 20	Distinct, milky.	V. slight.	0.15	10.10	-	.0004	.0042	-	-	.50	.0070	.0000	3.5
8255	Nov. 8	Nov. 11	Decided, milky.	Heavy.	0.04	26.40	-	.0008	.0270	-	-	.42	.0200	.0001	11.6
8344	Dec. 17	Dec. 18	V. slight.	None.	0.02	12.00	-	.0080	.0024	-	-	.56	.0040	.0001	5.0
Av.	....	....	....	....	0.13	12.96	-	.0016	.0063	-	-	.43	.0094	.0001	5.1

Odor, generally disagreeable, sometimes offensive. —— The samples were collected from a faucet in the pumping station, with the exception of Nos. 7826, 7945, 8142 and 8344, which were collected from a faucet in the town.

The water contains iron in solution, which precipitates out as a reddish-brown deposit on exposure to the air. Waters of this character often have a disagreeable odor from carburetted or sulphuretted hydrogen (compare the waters from wells near Attleborough, pages 66 and 67). Sample No. 8255 is exceptional in the series, containing much more mineral and organic matter than the other samples. The amount of metallic iron in this sample was 1.33 parts per 100,000, or 0.78 grain per gallon. The colors given in the table are doubtless all due to the separation of iron oxide. The water as it comes from the ground is colorless.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	May.	July.	Aug.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	29	28	8	1	13	19	17	21	12	18
Number of sample,	7247	7366	7543	7739	7782	7826	7945	8142	8255	8344
PLANTS.										
Fungi,	**0**	**0**	**0**	**23**	**102**	**556**	**0**	**0**	**0**	**1**
Crenothrix,	0	0	0	21	16	0	0	0	0	1
Molds,	0	0	0	2	86	556	0	0	0	0

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.									
	Jan.	May.	July.	Aug.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.										
Infusoria,	0	11	0	0	0	0	0	0	0	70
Dinobryon,	0	0	0	0	0	0	0	0	0	70
Vorticella,	0	11	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	2,856	176	672	1,800	932	300	542	230	204	35
TOTAL,	2,856	187	672	1,823	1,034	856	542	230	204	106

WATER SUPPLY OF REVERE AND WINTHROP. — REVERE WATER COMPANY.

An additional supply of water, obtained from a system of tubular wells in Saugus, was introduced Aug. 5, 1891. These wells are located near the junction of two brooks, a short distance east of the Newburyport Turnpike and about one-third of a mile northwest of the Pleasant Hill station on the Saugus branch of the Boston and Maine Railroad. The system consists of five two-inch and nine two and one-half-inch tubular wells. The five two-inch wells were driven several years ago and have an average depth of about 75 feet. The remaining wells were driven during the summer of 1891 and have an average depth of about 67 feet, the shortest being 34 feet deep and the longest 97 feet deep. This source is connected with the original wells at Revere by a sixteen-inch wrought-iron cement-lined pipe about 4½ miles long. Water was pumped to the wells at Revere from August to November, 1891, by means of a temporary pumping plant. A permanent pumping plant is to be constructed, as the yield from this system has been satisfactory during the time water has been drawn from it.

REVERE.

Chemical Examination of Water from Tubular Wells of the Revere Water Company at Cliftondale, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7884	Sept. 2	Sept. 3	None.	None.	0.0	11.50	.0018	.0014	.88	.0100	.0000	5.3

Odor, none. —— The sample was collected from a faucet at the temporary pumping station.

Microscopical Examination.

No organisms.

Water Supply of Salem and Beverly.

Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6890	Jan. 13	Jan. 14	V. slight.	None.	0.10	4.50	1.00	.0002	.0142	.0118	.0024	.79	.0280	.0000	2.5
6992	Feb. 9	Feb. 10	V. slight.	V. slight.	0.10	4.70	1.05	.0004	.0134	.0114	.0020	.69	.0150	.0001	2.1
7103	Mar. 10	Mar. 11	Distinct.	Cons., green.	0.05	4.80	1.15	.0004	.0146	.0106	.0040	.81	.0300	.0001	2.3
7208	Apr. 13	Apr. 14	Distinct.	V. slight.	0.10	4.95	0.95	.0000	.0096	.0078	.0018	.82	.0300	.0000	2.2
7298	May 11	May 12	Slight.	V. slight.	0.10	5.00	1.45	.0006	.0188	.0108	.0080	.68	.0030	.0000	1.8
7407	June 8	June 10	None.	V. slight.	0.05	4.70	0.75	.0010	.0140	.0122	.0018	.66	.0090	.0001	1.4
7550	July 13	July 14	Slight.	Slight.	0.05	4.20	1.20	.0000	.0164	.0124	.0040	.60	.0020	.0000	1.7
7781	Aug. 11	Aug. 11	Distinct.	Slight.	0.02	5.10	0.60	.0028	.0194	.0164	.0030	.71	.0050	.0000	1.9
7971	Sept. 23	Sept. 24	V. slight.	V. slight.	0.00	4.55	2.50	.0014	.0140	.0120	.0020	.69	.0070	.0000	1.7
8025	Oct. 7	Oct. 8	Slight.	V. slight.	0.20	4.40	1.00	.0000	.0150	.0130	.0020	.68	.0070	.0000	1.7
8310	Dec. 7	Dec. 8	Slight.	Cons.	0.10	4.75	1.85	.0006	.0200	.0126	.0074	.70	.0050	.0000	1.8
8368	Dec. 23	Dec. 24	V. slight.	Slight.	0.03	4.70	1.30	.0000	.0072	.0046	.0026	.72	.0090	.0000	1.7
Av.	....	....	....	....	0.07	4.70	1.12	.0006	.0147	.0113	.0034	.72	.0125	.0000	1.9

Odor, generally distinctly vegetable; in June and August, none. —— The samples were collected from faucets at the pumping station while pumping.

SALEM.

Microscopical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.	Dec.
Day of examination,	14	11	11	16	13	9	14	13	24	8	9	24
Number of sample,	6890	6992	7103	7208	7298	7407	7550	7781	7971	8025	8310	8368
PLANTS.												
Diatomaceæ,	**563**	**606**	**1,081**	**1,967**	**474**	**94**	**106**	**62**	**24**	**34**	**1,094**	**1,139**
Asterionella,	240	490	594	1,384	294	1	0	46	0	7	600	924
Cyclotella,	0	0	0	0	4	pr.	100	16	pr.	19	50	71
Diatoma,	0	0	0	0	pr.	1	3	0	12	2	1	0
Fragilaria,	0	0	0	3	0	0	0	0	3	5	8	11
Melosira,	216	25	210	426	58	0	8	0	0	0	344	76
Nitzschia,	15	62	0	22	0	18	0	0	0	0	0	0
Pinnularia,	0	0	118	0	0	0	0	0	0	0	0	0
Stephanodiscus,	12	18	15	46	36	69	0	0	0	pr.	82	0
Synedra,	80	10	92	80	64	1	0	0	0	0	9	3
Tabellaria,	0	1	52	6	18	4	0	0	9	1	0	54
Cyanophyceæ,	**1**	**0**	**1**	**3**	**0**	**3**	**108**	**24**	**10**	**44**	**1**	**21**
Anabæna,	0	0	0	0	0	0	0	17	0	0	0	0
Chroöcoccus,	0	0	0	3	0	0	60	4	5	37	0	21
Clathrocystis,	1	0	0	0	0	0	pr.	2	0	2	0	0
Cœlosphærium,	0	0	pr.	0	0	0	34	0	5	1	1	0
Microcystis,	0	0	1	0	0	3	14	1	pr.	4	0	0
Algæ,	**1**	**1**	**10**	**18**	**13**	**3**	**95**	**0**	**16**	**6**	**0**	**15**
Chlorococcus,	0	0	3	11	4	2	88	0	16	6	0	13
Raphidium,	0	0	5	3	0	0	7	0	0	0	0	1
Scenedesmus,	1	1	2	4	9	1	pr.	0	0	0	0	1
ANIMALS.												
Infusoria,	**8**	**10**	**6**	**8**	**pr.**	**0**	**0**	**pr.**	**20**	**30**	**10**	**pr.**
Dinobryon,	8	10	2	4	pr.	0	0	0	20	30	0	0
Monas,	0	0	0	1	0	0	0	0	0	pr.	2	pr.
Peridinium,	0	pr.	2	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	2	3	0	0	0	pr.	0	pr.	8	0
Crustacea,	**pr.**	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**pr.**	**pr.**	**pr.**	**0**
Cyclops,	pr.	0	0	0	0	0	pr.	0	pr.	pr.	pr.	0
Daphnia,	0	0	0	0	0	0	pr.	0	0	0	0	0
Miscellaneous. Zoöglœa,	**76**	**58**	**440**	**184**	**58**	**4**	**7**	**54**	**35**	**126**	**176**	**39**
TOTAL,	649	675	1,538	2,180	545	104	316	140	105	240	1,281	1,214

SALEM.

Table showing Heights of Water in Wenham Lake at Times when Samples of Water were collected for Analysis.

NOTE.—High-water mark is 30.17 feet.

DATE.	Height of Water.	DATE.	Height of Water.
1891.	Feet.	1891.	Feet.
Jan. 13,	29.5	July 13,	28.9
Feb. 9,	30.1	Aug. 11,	28.1
Mar. 10,	29.8	Sept. 23,	26.8
Apr. 13,	30.2	Oct. 7,	26.3
May 11,	29.9	Dec. 7,	25.3
June 8,	29.7	Dec. 23,	25.0

WATER SUPPLY OF SAUGUS.

(See *Lynn.*)

WATER SUPPLY OF SOMERVILLE.

(See *Boston, Mystic Works*)

WATER SUPPLY OF SOUTHBRIDGE. — SOUTHBRIDGE WATER COMPANY.

An additional storage reservoir, having an area of 3.4 acres, was built in 1888 at the upper end of the brook above the original storage reservoir. The new reservoir is said to store 10,500,000 gallons. Its maximum depth is 20 feet at the dam, and by means of flash boards an extra foot of water can be held, giving an additional storage of 1,125,000 gallons. The bottom of the reservoir was cleaned by removing the soil and also by taking from it the material for the dam.

WATER SUPPLY OF SOUTH HADLEY FALLS FIRE DISTRICT, SOUTH HADLEY.

An additional storage reservoir has been constructed on Leaping Well Brook, which is about two and a half miles northerly from South Hadley Falls and about one and a fourth miles north of the old reservoir. The new reservoir has an area of 9.2 acres and holds about 28,000,000 gallons. It is 26 feet in depth at the dam and its average depth is 9.3 feet. When the reservoir is drawn down four feet below high-water mark its area is reduced to 6.8 acres, and when

drawn down eight feet its area is further reduced to 4.7 acres. The bottom is sandy, all loam and vegetable matter having been removed before it was filled. The reservoir is at the same height as the old one, and they can be used separately or together. The gate-house of the new reservoir is so arranged that water may be drawn from different depths and may be wasted from the bottom if desired.

Chemical Examination of Water from Leaping Well Brook where it enters the new Storage Reservoir of the South Hadley Falls Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8374	Dec. 28	Dec. 31	V. slight.	Cons.	0.02	3.25	0.35	.0000	.0028	.0012	.0016	.11	.0030	.0000	0.6

Odor, none.

Microscopical Examination.

Fungi, *Crenothrix*, 13; *Molds*, 2. Miscellaneous, *Zoöglœa*, 21. Total, 36.

Water Supply of Springfield.

As stated in previous reports of the Board, the main source of supply for the city of Springfield has been a large storage reservoir in the town of Ludlow, which received its supply in part from small brooks which naturally flowed into it, and in part from other brooks in the vicinity which were diverted into it by open canals. The water of this reservoir is subject to offensive tastes and odors every summer and autumn, caused mainly by the regular recurrence of enormous growths of blue-green algæ. After an extended investigation of possible remedies for the troubles which affected the water and of new sources of supply, it was decided to abandon the reservoir as a source, and to obtain a supply from the brooks which had already been diverted into the reservoir, and from a new source, Jabish Brook in Belchertown. The gate-house which controlled the flow of water from the Ludlow Reservoir to the city is still retained, also a small basin in connection with it, formed by throwing a dam across an arm of the Ludlow Reservoir. Water from all of the

brooks now furnishing a supply is brought by means of an extensive system of canals either into this basin, or directly into the gate-house.

The total area of the water-sheds now tributary to the canal system is about 18.5 square miles.

Jabish Brook rises in Pelham, and, flowing in a southerly direction through Belchertown, enters the Swift River about two miles above the village of Three Rivers. Its waters are diverted at the Blackmer & Walker mill-pond in Belchertown, about four miles above the mouth of the brook. The area of the water-shed above the point of diversion, as measured from the State map, is 10.6 square miles, and is generally hilly and free from swamps. The population upon it, with the exception of a portion of the village of Belchertown, is scattered and generally remote from the streams. Along the main stream, above the point of taking, there are several small mills, nearly all of them wood-working establishments. The first mill-pond on the stream above the point where the water is diverted is quite large and very shallow. The two ponds highest up the stream have been purchased by the city and will be used as storage reservoirs. The lower of these ponds was originally formed by flooding a timbered swamp to a slight depth, and it has been enlarged and deepened by the construction of a new dam, about five feet higher than the original one. The reservoir is now said to have an area of 52.4 acres, a depth of 13 feet at the dam, and a storage capacity of 194,000,000 gallons when full. The bottom of the reservoir has not been cleaned, and over most of its area stumps are yet standing, which were cut off at the level of high water in the original pond about seventy-six years ago. The new dam was completed Jan. 1, 1892. The upper pond is much smaller than the lower one, and remains as yet in the same condition as when purchased.

The water stored in these reservoirs will be used to maintain the flow in the stream when necessary, and particularly on Sundays during the dryer portion of the year, when, owing to the shutting down of the mills, little or no water would otherwise flow past the dams farther down stream.

The old dam at the Blackmer & Walker Pond has been replaced by a new one, built of stone, but otherwise the pond has not been changed.

The canal for diverting the water starts from the upper end of the mill-pond, with its bottom four feet below high-water mark, and runs to the gate-house of the Ludlow Reservoir, a total distance of 6.88 miles. The canal is of uniform section, 8 feet wide on the bottom, with side slopes of 1½ horizontal to 1 vertical throughout the whole distance, except at two points, where, in order to cross Broad Brook and Cherry Valley just below the dam of the Ludlow Reservoir, fifty-four-inch wrought-iron pipes are substituted. It receives in its course the water of Broad Brook and Axe Factory Brook, the former through a branch canal about 3,200 feet long. The total fall of the main canal is 42 feet. Much of the way the inclination is less than 1 in 9,000, but in one place in the upper portion of its course the inclination is 1 in 83⅓ for half a mile. The last 6,000 feet is located close to the edge of the Ludlow Reservoir, with the bottom of the canal five feet below the level of the water in the reservoir.

The Higher Brook canal remains as before, but a pipe has been laid from its former point of discharge into the Ludlow Reservoir, to convey its waters directly to the basin near the Ludlow gate-house.

The basin is about 900 feet long, and has an area of about 12 acres and a storage capacity of about 50,000,000 gallons when full. A thirty-six-inch iron pipe, 133 feet long, has been laid through the dam which separates the basin from the main reservoir, by which surplus water can be discharged into the reservoir when more than the required quantity is brought by the canals, or through which a supply can be drawn from the main reservoir into the basin if an emergency ever makes it necessary to take water from this source.

The surplus water brought by the canals can be diverted into the basin or directly into the main reservoir, and from all sources except Higher Brook the water can be turned directly into the gate-house if desired, and in this way sent directly to the city without admixture with the water in the basin. It has been the policy to discharge as much surplus water as possible into the basin, and allow it to flow thence into the main reservoir through the thirty-six-inch pipe above mentioned. This is done with a view to changing the water in the basin as often as possible, and thus preventing growths of algæ and consequent disagreeable tastes and odors. Growths of algæ, how-

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ever, appeared in the basin in 1891, and for this reason water from the canal was turned directly through the gate-house to the city until late in the season.

The various portions of the works were completed at different times as follows: The basin was completed early in the fall of 1890 and Higher Brook was diverted into it Nov. 22, 1890. Water from Broad and Axe Factory brooks was turned into the basin May 18, 1891, but was shut off, owing to a leak in the wrought-iron siphon around the Cherry Valley dam, and was turned on again June 2, 1891. During this interval a part of the water was drawn from the main reservoir. Water from Jabish Brook was first turned through the canal June 20, 1891.

Chemical Examination of Water from the Gate-house of the Ludlow Reservoir, Springfield Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.	
	1891.														
6923	Jan. 20	Jan. 21	V. slight.	Slight.	0.25	2.75	0.75	.0022	.0226	.0172	.0054	.08	.0050	.0001	0.8
7022	Feb. 16	Feb. 17	Slight.	V. slight.	0.20	2.70	0.85	.0006	.0170	.0126	.0044	.06	.0070	.0001	0.9
7120	Mar. 16	Mar. 17	V. slight.	Slight.	0.15	2.30	0.90	.0002	.0078	.0062	.0016	.04	.0070	0000	0.6
7227	Apr. 20	Apr. 21	Slight.	Cons., green.	0.30	2.25	1.00	0000	.0136	.0088	.0048	.06	.0070	.0000	0.8
7327	May 18	May 19	Slight.	Cons., green	0.20	2.70	1.25	.0010	.0348	.0184	.0164	.08	.0050	.0000	0.6
7443	June 15	June 16	Distinct, green.	Cons.	0.25	2.35	0.85	.0076	.0512	.0238	.0274	.07	.0050	.0001	0.9
7570	July 20	July 21	V. slight.	Slight.	0.60	4.30	2.10	.0004	.0298	.0238	.0060	.09	.0000	.0000	1.1
7839	Aug. 19	Aug. 21	Distinct.	Cons., brown.	0.25	3.85	1.10	.0000	.0186	.0126	.0060	.09	.0020	.0001	1.1
7923	Sept. 14	Sept. 15	Slight.	Cons.	0.40	4.65	1.80	.0000	.0232	.0182	.0050	.13	.0020	.0000	1.1
8238	Nov. 9	Nov. 10	Slight.	Slight.	0.30	4.15	1.50	.0002	.0170	.0104	.0066	.12	.0050	.0002	1.6
8328	Dec. 14	Dec. 15	V. slight.	V. slight.	0.50	4.00	1.10	.0000	.0114	.0096	.0018	.16	.0090	.0002	1.4
Av.	....	....	....	....	0.31	3.27	1.20	.0011	.0225	.0147	.0078	.09	.0049	.0001	1.0

Odor, faintly vegetable and grassy, frequently none; in May and June, strongly vegetable and grassy. The odor generally increased on heating. —— The samples were collected from the gate-chamber, and represent the water sent to the city. The water came at times directly from the canals, at other times from the basin, and occasionally in part from the Ludlow Reservoir.

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Microscopical Examination of Water from the Gate-house of the Ludlow Reservoir, Springfield Water Works.

[Number of organisms per cubic centimeter.]

	1891.										
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Nov.	Dec.
Day of examination,	22	18	18	21	20	16	21	21	15	11	16
Number of sample,	6923	7022	7120	7227	7327	7443	7570	7839	7923	8238	8328
PLANTS.											
Diatomaceæ,	**86**	**112**	**42**	**1,107**	**56**	**2**	**539**	**362**	**235**	**584**	**12**
Asterionella,	18	15	5	82	6	0	0	14	14	482	0
Cyclotella,	0	0	0	0	0	0	6	0	1	7	0
Fragilaria,	0	0	0	17	0	0	0	0	0	1	0
Melosira,	66	90	25	998	50	0	528	318	210	48	7
Meridion,	pr.	0	4	2	0	0	0	0	0	pr.	1
Navicula,	pr.	0	1	7	0	0	5	28	6	2	2
Nitzschia,	1	0	5	0	0	0	0	0	0	0	0
Synedra,	1	7	2	1	0	pr.	pr.	0	2	44	2
Tabellaria,	0	pr.	0	0	0	2	pr.	2	2	pr.	0
Cyanophyceæ,	**pr.**	**pr.**	**pr.**	**16**	**168**	**249**	**23**	**56**	**33**	**143**	**0**
Anabæna,	0	0	0	pr.	0	246	9	1	2	8	0
Aphanocapsa,	0	0	0	1	0	0	3	2	0	2	0
Chroöcoccus,	0	0	0	7	160	0	0	4	0	76	0
Clathrocystis,	pr.	pr.	pr.	3	2	3	3	32	14	9	0
Cœlosphærium,	0	0	pr.	5	3	0	2	16	16	9	0
Microcystis,	0	0	0	0	3	0	6	1	1	44	0
Algæ,	**87**	**10**	**4**	**20**	**368**	**347**	**131**	**5**	**30**	**151**	**pr.**
Chlorococcus,	0	10	0	0	264	6	71	0	18	58	0
Closterium,	0	0	1	pr.	0	0	0	0	1	12	0
Pandorina,	0	0	0	0	0	0	7	1	0	0	0
Podiastrum,	0	0	pr.	pr.	2	0	2	pr.	0	pr.	0
Protococcus,	84	0	3	0	0	0	0	0	0	0	0
Raphidium,	0	0	0	pr.	8	0	1	0	0	15	0
Scenedesmus,	3	0	pr.	18	52	0	34	2	8	66	pr.
Staurastrum,	0	pr.	0	2	32	1	16	2	2	0	0
Zoöspores,	0	0	0	0	10	340	0	0	1	0	0
Fungi. Crenothrix,	**0**	**0**	**1**	**0**	**0**	**0**	**pr.**	**0**	**4**	**1**	**1**
ANIMALS.											
Rhizopoda. Actinophrys,	**pr.**	**1**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**pr.**
Infusoria,	**166**	**148**	**33**	**0**	**356**	**2**	**4**	**5**	**176**	**30**	**21**
Dinobryon,	0	82	6	0	356	0	0	0	175	4	21
Dinobryon cases,	114	0	0	0	0	0	0	0	0	10	0
Glenodinium,	0	0	0	0	0	0	2	0	0	0	0
Monas,	0	0	24	0	0	0	pr.	0	0	2	0
Peridinium,	52	66	3	0	0	0	1	3	0	7	pr.
Trachelomonas,	0	pr.	0	0	0	2	1	2	1	7	0
Vermes,	**0**	**2**	**0**	**pr.**	**3**	**0**	**0**	**1**	**0**	**0**	**0**
Anurea,	0	pr.	0	pr.	1	0	0	1	0	0	0
Asplanchna,	0	0	0	0	2	0	0	0	0	0	0
Polyarthra,	0	2	0	0	0	0	0	pr.	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**pr.**	**pr.**	**1**	**pr.**	**0**
Bosmina,	0	0	0	0	pr.	0	0	0	0	pr.	0
Cyclops,	0	0	0	0	0	pr.	pr	pr.	0	0	0
Entomostracan ova,	0	0	0	0	0	0	0	0	1	pr.	0
Miscellaneous. Zoöglœa,	**158**	**84**	**86**	**396**	**17**	**16**	**143**	**144**	**300**	**134**	**3**
TOTAL,	497	357	173	1,539	968	616	840	573	779	1,045	37

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Chemical Examination of Water from the Canal which conveys Water from Jabish, Axe Factory and Broad Brooks to the Basin and Gate-house at Ludlow Reservoir.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
7574	July 20	July 21	V. slight.	Slight.	0.80	6.10	2.90	.0000	.0196	.0164	.0032	.13	.0030	.0000	1.1
8035	Oct. 12	Oct. 13	V. slight.	V. slight, white.	0.25	3.00	1.60	.0004	.0164	.0146	.0018	.14	.0000	.0005	-

Odor, very faintly vegetable.——The samples were collected from the canal at its outlet.

Microscopical Examination.

No. 7574. Diatomaceæ, *Cocconeis*, 1; *Cyclotella*, 1; *Navicula*, 9; *Synedra*, 10. Cyanophyceæ, *Chroöcoccus*, 4. Algæ, *Chlorococcus*, 1; *Pandorina*, pr.; *Staurastrum*, pr. Fungi, *Crenothrix*, 2. Infusoria, *Dinobryon cases*, 18. Vermes, *Anurea*, pr. Miscellaneous, *Zoöglœa*, 142. Total, 188.

No. 8035. Diatomaceæ, *Cyclotella*, 1; *Diatoma*, pr.; *Fragilaria*, 1; *Navicula*, 2; *Surirella*, pr.; *Tabellaria*, 1. Cyanophyceæ, *Nostoc*, pr. Algæ, *Staurastrum*, 1. Infusoria, *Dinobryon*, 11; *Peridinium*, 1; *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 6. Total, 25.

Chemical Examination of Water from Higher Brook, in Ludlow.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
7021	Feb. 16	Feb. 17	V. slight.	V. slight.	0.20	3.10	1.00	.0006	.0084	.0060	.0024	.04	.0070	.0002	1.1

Odor, none.——The sample was collected from the brook near the dam.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2; *Gomphonema*, pr.; *Meridion*, 9; *Navicula*, 1; *Synedra*, 27; *Tabellaria*, 3. Algæ, *Chlorococcus*, 1; *Cosmarium*, 1. Infusoria, *Peridinium*, pr. Miscellaneous, *Zoöglœa*, 80; *Starch grains*, 1. Total, 125.

SPRINGFIELD.

Chemical Examination of Water from the Basin of the Springfield Water Works at Ludlow Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7573	July 20	July 21	Slight.	Cons., green.	.06	5.70	2.00	.0008	.0334	.0208	.0126	.10	.0030	.0000	0.9

Odor, none, becoming vegetable on standing.——The sample was collected from the basin one hundred feet from shore. The basin was formerly an arm of Ludlow Reservoir, but is now separated from it by a dam.

Microscopical Examination.

Diatomaceæ, *Cymbella*, 1; *Fragilaria*, 4; *Melosira*, 301; *Navicula*, 1. Cyanophyceæ, *Aphanocapsa*, 4; *Clathrocystis*, 2; *Cœlosphærium*, 2; *Microcystis*, 3. Algæ, *Pandorina*, 221; *Pediastrum*, pr.; *Scenedesmus*, 15; *Staurastrum*, 10. Fungi, *Crenothrix*, 1. Infusoria, *Trachelomonas*, pr. Crustacea, *Cyclops*, 1. Miscellaneous, *Zoöglœa*, 153. Total, 719.

Chemical Examination of Water from Ludlow Reservoir, at a depth of six feet beneath the surface.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6924	Jan. 20	Jan. 21	Slight.	V. slight.	0.20	2.70	1.20	.0180	.0394	.0246	.0148	.08	.0050	.0001	0.8
7023	Feb. 16	Feb. 17	V. slight.	Slight.	0.15	2.75	1.20	.0060	.0280	.0188	.0092	.08	.0070	.0001	0.9
7121	Mar. 16	Mar. 17	Slight.	Slight.	0.10	2.75	0.95	.0012	.0320	.0148	.0172	.10	.0070	.0000	1.1
7228	Apr. 20	Apr. 21	Slight.	Cons., green.	0.10	1.95	0.75	.0000	.0180	.0140	.0040	.08	.0070	.0000	0.8
7328	May 18	May 19	Slight.	Cons., green.	0.20	2.60	1.60	.0002	.0358	.0182	.0176	.07	.0070	.0000	0.5
7444	June 15	June 16	Distinct.	Heavy.	0.25	3.30	2.05	.0014	.0844	.0280	.0564	.09	.0050	.0000	0.6
7571	July 20	July 21	Slight.	Cons., green.	0.60	3.60	2.00	.0332	.0456	.0346	.0110	.08	.0000	.0000	0.6
7864	Aug 27	Aug. 28	Decided, green.	Cons.	0.20	2.95	1.00	.0004	.0384	.0208	.0176	.10	.0020	.0000	0.8
7925	Sept. 14	Sept. 15	Distinct.	Cons., green.	0.10	3.20	1.70	.0000	.0434	.0224	.0210	.09	.0000	.0000	0.8
8037	Oct. 12	Oct. 13	Decided.	Heavy.	0.10	4.00	1.40	.0000	.0638	.0268	.0370	.10	.0000	.0007	0.8
8230	Nov. 9	Nov. 10	Distinct.	Cons., green.	0.15	2.80	1.55	.0002	.0418	.0288	.0130	.10	.0150	.0001	0.5
8329	Dec. 14	Dec. 15	Distinct.	Cons.	0.20	3.40	1.65	.0000	.0390	.0220	.0170	.12	.0050	.0005	0.9
Av.	....	....	....	....	0.20	3.00	1.42	.0050	.0425	.0228	.0197	.09	.0050	.0001	0.8

Odor, generally distinctly vegetable and grassy, sometimes unpleasant, occasionally none; becomes somewhat stronger on heating. ——The samples were collected from near the middle of the reservoir at a depth of six feet beneath the surface, with the exception of No. 8329, which was collected from near the Cherry Valley waste-way at a depth of three feet beneath the surface. For heights of water in the reservoir at times when samples of water were collected see page 214. This reservoir is not now used as a source of water supply except in emergencies.

SPRINGFIELD.

Microscopical Examination of Water from Ludlow Reservoir, at a depth of six feet beneath the surface.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	22	18	18	22	20	16	21	29	15	13	11	16
Number of sample,	6924	7023	7121	7228	7328	7444	7571	7864	7925	8037	8239	8329
PLANTS.												
Diatomaceæ,	**67**	**72**	**83**	**5,228**	**518**	**0**	**77**	**34**	**429**	**456**	**1,725**	**497**
Asterionella,	17	5	13	286	100	0	0	0	20	116	1,358	384
Cyclotella,	0	0	0	0	0	0	3	pr.	0	1	3	1
Fragilaria,	0	0	0	0	4	0	38	0	0	0	0	0
Melosira,	48	64	70	4,940	412	0	36	31	408	328	312	90
Navicula,	0	0	0	0	2	0	pr.	2	1	0	pr.	4
Synedra,	2	3	0	0	0	0	0	1	0	3	52	18
Tabellaria,	0	0	0	2	0	0	0	0	0	8	0	0
Cyanophyceæ,	**1**	**pr.**	**19**	**19**	**95**	**464**	**129**	**0**	**722**	**796**	**168**	**20**
Anabæna,	0	0	0	0	0	464	35	0	84	28	pr.	0
Aphanocapsa,	0	pr.	0	1	7	0	2	0	5	9	6	1
Chroöcoccus,	0	0	9	14	40	0	0	0	17	19	58	4
Clathrocystis,	1	0	9	3	2	0	77	0	120	72	30	4
Cœlosphærium,	0	0	1	1	10	0	11	0	404	364	4	3
Microcystis,	0	0	0	0	36	0	4	0	92	304	70	8
Algæ,	**27**	**59**	**35**	**43**	**825**	**8**	**424**	**1**	**136**	**137**	**330**	**135**
Botrycoccus,	0	0	0	0	0	0	0	0	0	0	16	0
Chlorococcus,	0	0	5	17	508	8	296	0	24	69	96	0
Closterium,	0	0	3	pr.	0	0	pr.	pr.	1	2	26	14
Cosmarium,	0	0	0	0	1	0	5	1	0	0	2	0
Pediastrum,	0	0	0	1	3	0	12	0	1	7	2	0
Protococcus,	8	58	0	0	0	0	0	0	0	0	0	0
Raphidium,	14	pr.	2	2	11	0	0	0	26	0	32	8
Scenedesmus,	5	1	1	20	108	pr.	27	0	76	48	154	112
Staurastrum,	pr.	0	0	3	14	pr.	84	0	8	11	2	1
Zoöspores,	0	0	24	0	180	0	0	0	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**
ANIMALS.												
Rhizopoda. Actinophrys,	**1**	**0**	**38**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**
Infusoria,	**142**	**142**	**533**	**62**	**473**	**pr.**	**1**	**1**	**37**	**21**	**12**	**21**
Dinobryon,	28	80	128	0	472	0	0	0	0	0	0	9
Euglena,	0	0	0	0	0	0	0	0	2	1	0	1
Glenodinium,	0	0	0	0	0	0	0	1	1	0	0	0
Monas,	0	pr.	5	0	0	pr.	0	0	0	1	pr.	1
Peridinium,	114	62	398	62	0	0	1	0	0	9	8	9
Trachelomonas,	0	0	2	0	1	0	0	pr.	34	10	4	1
Vermes,	**3**	**3**	**5**	**2**	**1**	**1**	**pr.**	**0**	**0**	**1**	**0**	**6**
Anurea,	3	1	2	2	1	1	pr.	0	0	1	0	1
Polyarthra,	0	pr.	1	0	0	0	0	0	0	0	0	1
Rotatorian ova,	0	2	0	0	0	0	0	0	0	0	0	4
Rotifer,	0	pr.	2	0	0	0	0	0	0	0	0	0
Crustacea,	**0**	**0**	**pr.**	**0**	**pr.**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**pr.**	**pr.**
Bosmina,	0	0	pr.	0	pr.	0	0	0	0	0	pr.	0
Cyclops,	0	0	0	0	0	pr.	pr.	0	pr.	pr.	pr.	pr.
Miscellaneous. Zoöglœa,	**332**	**150**	**166**	**382**	**160**	**0**	**73**	**30**	**432**	**304**	**244**	**120**
TOTAL,	578	426	879	5,736	2,072	473	704	72	1,758	1,715	2,479	799

SPRINGFIELD.

Chemical Examination of Water from Ludlow Reservoir, collected at from two to four feet above the bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6925	Jan. 20	Jan. 21	Slight.	Slight.	0.25	2.30	1.45	.0190	.0334	.0240	.0094	.08	.0050	.0001	0.8
7024	Feb. 16	Feb. 17	Distinct.	Cons.	0.35	3.10	1.65	.0326	.0284	.0196	.0088	.06	.0070	.0002	0.8
7122	Mar. 16	Mar. 17	Distinct.	Slight, green.	0.40	3.50	1.70	.0138	.0312	.0184	.0128	.07	.0050	.0000	1.3
7229	Apr. 20	Apr. 21	Slight.	Cons., green.	0.10	2.15	1.30	.0000	.0218	.0124	.0094	.08	.0050	.0000	0.6
7329	May 18	May 19	Distinct, green.	Heavy, green.	0.15	2.35	1.10	.0010	.0356	.0218	.0138	.06	.0110	.0000	0.5
7445	June 15	June 16	Distinct.	Heavy.	0.30	2.80	1.40	.0286	.0410	.0206	.0204	.10	.0060	.0000	0.6
7572	July 20	July 21	Slight.	Cons., green.	0.60	3.60	2.05	.0214	.0598	.0400	.0198	.08	.0050	.0000	0.5
7840	Aug. 19	Aug. 21	Decided, green.	Cons., rusty.	0.20	2.90	1.50	.0000	.0410	.0220	.0190	.12	.0070	.0001	0.8
7924	Sept. 14	Sept. 15	Distinct.	Cons., green.	0.10	3.75	2.00	.0002	.0474	.0236	.0238	.10	.0000	.0000	0.8
Av.	....	....	....	....	0.27	2.94	1.57	.0130	.0377	.0225	.0152	.08	.0057	.0000	0.7

Odor, generally distinctly vegetable and grassy, sometimes unpleasant, rarely none.——The samples were collected from the reservoir near the middle and from two to four feet above the bottom. For heights of water in the reservoir at times when samples of water were collected see page 214. This reservoir is not now used as a source of water supply except in emergencies.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
Day of examination,	22	18	18	22	20	16	22	21	15
Number of sample,	6925	7024	7122	7229	7329	7445	7572	7840	7924
PLANTS.									
Diatomaceæ,	**87**	**70**	**33**	**4,460**	**287**	**0**	**80**	**264**	**294**
Asterionella,	17	8	3	174	11	0	3	2	12
Diatoma,	0	0	0	12	0	0	0	0	0
Melosira,	68	60	30	4,274	276	0	77	262	282
Synedra,	2	2	pr.	0	0	0	pr.	0	0
Cyanophyceæ,	**2**	**93**	**55**	**28**	**75**	**88**	**52**	**429**	**848**
Anabæna,	0	0	0	0	3	88	7	92	80
Aphanocapsa,	0	6	0	2	4	0	2	40	1
Chroöcoccus,	0	0	1	22	0	0	0	0	177
Clathrocystis,	2	82	54	2	1	pr.	35	162	156
Cœlosphærium,	0	5	pr.	2	3	0	7	120	432
Microcystis,	0	0	0	0	64	0	1	7	2
Nostoc spores,	0	0	0	0	0	0	0	8	0

SPRINGFIELD.

Microscopical Examination — Concluded.

	1891.								
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
PLANTS — Con.									
Algæ,	14	1	44	138	663	17	690	25	130
Chlorococcus,	0	0	11	76	384	12	474	0	20
Cosmarium,	0	0	0	0	0	0	10	0	0
Pandorina,	0	0	0	0	0	0	3	0	2
Pediastrum,	0	0	0	1	2	pr.	13	2	2
Protococcus,	6	0	0	0	0	0	0	0	0
Raphidium,	4	0	8	0	2	0	4	0	12
Scenedesmus,	3	1	5	58	112	pr.	44	15	76
Staurastrum,	1	0	pr.	3	7	5	142	8	18
Zoöspores,	0	0	20	0	156	0	0	0	0
Fungi. Micrococcus,	0	0	0	6	0	0	0	0	0
ANIMALS.									
Rhizopoda. Actinophrys,	1	0	12	0	2	0	1	0	0
Infusoria,	33	10	194	32	332	0	10	4	36
Dinobryon,	1	5	25	0	332	0	0	0	0
Monas,	0	0	3	0	0	0	5	0	2
Peridinium,	32	5	166	32	0	0	0	4	0
Trachelomonas,	0	0	0	0	0	0	5	0	34
Vermes,	3	18	3	pr.	0	0	0	0	0
Anurea,	2	16	3	pr.	0	0	0	0	0
Polyarthra,	1	0	pr.	0	0	0	0	0	0
Rotatorian ova,	0	2	0	0	0	0	0	0	0
Crustacea,	0	0	0	0	0	pr.	pr.	pr.	pr.
Cyclops,	0	0	0	0	0	pr.	pr.	pr.	pr.
Daphnia,	0	0	0	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	496	1,110	596	870	440	20	97	244	396
TOTAL,	636	1,302	987	5,534	1,797	125	930	966	1,704

Table showing Heights of Water in Ludlow Reservoir at Times when Samples of Water were collected for Analysis.

NOTE.—Height of rollway, 23.00 feet.

DATE.	Height of Water.	DATE.	Height of Water.
Jan. 20,	12.50	July 20,	13.63
Feb. 16,	14.14	Aug. 19,	13.72
Mar. 16,	16.66	Sept. 14,	12.25
Apr. 20,	16.03	Oct. 12,	11.15
May 18,	15.20	Nov. 9,	11.37
June 15,	14.45	Dec. 14,	12.95

Sterling.

For chemical and microscopical examinations of water from East Waushacum Pond in Sterling see *Clinton*.

Water Supply of Stockbridge. — Stockbridge Water Company.

Chemical Examination of Water from Konkapot Brook and Lake Averic, in Stockbridge.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1891.														
7322	May 15	May 16	Slight.	Slight.	0.20	11.45	-	.0050	.0120	.0076	.0044	.06	.0130	.0002	10.3
8233	Nov. 5	Nov. 7	V. slight.	V. slight.	0.05	7.20	1.95	.0028	.0246	.0210	.0036	.07	.0100	.0002	4.7

Odor, vegetable.——No. 7322 was collected from Konkapot Brook; No. 8233 from Lake Averic. The samples were collected during an investigation for an additional water supply for Stockbridge. Works are now being constructed to take a supply from Lake Averic.

Microscopical Examination.

No. 7322. Diatomaceæ, *Cymbella*, 3; *Diatoma*, pr.; *Meridion*, 4; *Navicula*, 8; *Nitzschia*, 4; *Synedra*, 30. Algæ, *Chlorococcus*, 1; *Closterium*, pr. Fungi, *Crenothrix*, 110. Infusoria, *Euglena*, 4; *Paramæcium*, 1. Miscellaneous, *Zoöglœa*, 428. Total, 593.

No. 8233. Diatomaceæ, *Asterionella*, 180; *Cocconeis*, 1; *Cocconema*, 1; *Navicula*, 6; *Pleurosigma*, 1; *Synedra*, 7. Cyanophyceæ, *Nostoc*, 1. Algæ, *Closterium*, 1; *Raphidium*, 2; *Zoöspores*, 2. Fungi, *Molds*, 1. Infusoria, *Euglena*, 2; *Monas*, 2. Total, 207.

Water Supply of Stoneham.

(See *Wakefield*.)

Water Supply of Swampscott and Nahant. — Marblehead Water Company.

The number of tubular wells has been increased until there are now seventy-two in all connected with the works. These wells are about 40 feet in depth and are all within 300 feet of the large well, which was the original source of supply. The wells are located but a short distance from the ocean. Provision has been made by which water can be pumped for use either from the large well or from the tubular

SWAMPSCOTT.

wells. The analyses show that the water from the wells contains a greater amount of residue on evaporation, chlorine and nitrates, than in previous years. This is probably due in part to the proximity of the works to the ocean and the consequent infiltration of a very small amount of sea water, and it may also be due in part to the diversion of Stacy's Brook, which formerly flowed past the well, into the Lynn intercepting sewer. Some additional test wells were driven in Paradise Road in the autumn of 1891, about a third of a mile north-east of the present works, with a view to obtaining an additional supply from this source. These wells were tested by pumping from them for more than a week with a steam pump. Analyses of the water were also made, which will be found on page 217.

Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.	
	1891.											
7004	Feb. 11	Feb. 12	None.	None.	0.0	32.85	.0000	.0018	5.42	.9000	.0000	15.8
7114	Mar. 10	Mar. 13	None.	None.	0.0	34.80	.0002	.0018	5.44	.7500	.0002	17.5
7218	Apr. 15	Apr. 15	None.	None.	0.0	31.80	.0000	.0014	4.74	1.2500	.0000	16.4
7305	May 12	May 12	None.	None.	0.0	31.85	.0000	.0010	4.77	1.0000	.0000	15.5
7425	June 9	June 10	None.	None.	0.0	34.00	.0000	.0000	4.60	1.0000	.0000	14.4
7557	July 14	July 14	None.	None.	0.0	27.30	.0004	.0012	4.20	.9000	.0012	8.9
7785	Aug. 12	Aug. 12	None.	None.	0.0	32.20	.0180	.0014	-	.6000	.0005	14.2
7919	Sept. 14	Sept. 15	None.	None.	0.0	47.50	.0000	.0000	11.25	1.3000	.0000	23.6
8084	Oct. 13	Oct. 15	None.	None.	0.0	45.10	.0000	.0006	11.00	1.1000	.0003	23.6
8235	Nov. 9	Nov. 10	None.	None.	0.0	57.80	.0010	.0006	12.55	1.2000	.0000	23.3
8320	Dec. 9	Dec. 10	None.	None.	0.0	50.30	.0000	.0010	13.30	.9000	.0000	25.1
Av.	....	....	....	....	0.0	38.64	.0018	.0010	7.73	.9909	.0002	18.0

Odor, none.—— The samples were collected from a faucet at the pumping station while pumping.

SWAMPSCOTT.

Microscopical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.

[Number of organisms per cubic centimeter.]

	1891.										
	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	12	16	13	11	14	13	15	15	10	11
Number of sample,	7004	7114	7218	7305	7425	7557	7785	7919	8084	8235	8320
PLANTS.											
Diatomaceæ. Synedra,	5	0	pr.	0	0	0	0	pr.	0	pr.	0
Algæ. Chlorococcus,	0	0	0	0	13	0	0	0	0	0	0
TOTAL,	5	0	pr.	0	13	0	0	pr.	0	pr.	0

Chemical Examination of Water from Test Wells of the Marblehead Water Company on Paradise Road, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8143	Oct. 19	Oct. 20	None.	None.	0.0	12.00	.0000	.0004	.84	.0150	.0005	6.1
8167	Oct. 23	Oct. 23	Slight, clayey.	Slight, earthy.	0.0	10.60	.0000	.0000	.72	.0700	.0010	5.0
8175	Oct. 29	Oct. 30	None.	None.	0.0	10.40	.0000	.0006	.74	.0750	.0020	5.3

Odor, none.—— No. 8143 was collected from a tubular well which overflowed into the brook; the other samples from five tubular wells which were connected and tested by being pumped from for about a week. No. 8167 was collected near the beginning of the test and No. 8175 near the end of the test after 54 hours' continuous pumping.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891.		
	October.	October.	October.
Day of examination,	21	26	31
Number of sample,	8143	8167	8175
PLANTS.			
Algæ. Chlorococcus,	0	1	0
Miscellaneous. Zoöglœa,	3	45	7
TOTAL,	3	46	7

TAUNTON.

Water Supply of Taunton.

Chemical Examination of Water from the Filter-basin of the Taunton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid Total.	Ammonia. Albuminoid Dissolved.	Ammonia. Albuminoid Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6948	Jan. 26	Jan. 27	V.slight.	None.	0.50	4.10	1.45	.0014	.0118	-	-	.35	.0300	.0000	1.8
7050	Feb. 24	Feb. 24	V.slight.	Slight, rusty.	0.30	5.15	1.60	.0016	.0074	-	-	.51	.0300	.0000	1.9
7146	Mar. 26	Mar. 27	Slight.	V.slight.	0.25	3.55	0.65	.0006	.0070	.0054	.0016	.48	.0200	.0000	1.7
7246	Apr. 27	Apr. 28	V.slight.	Slight.	0.30	5.25	1.25	.0000	.0040	-	-	.53	.0250	.0000	1.7
7344	May 25	May 26	V.slight.	V.slight.	0.30	5.20	1.45	.0018	.0082	.0074	.0008	.55	.0200	.0000	1.7
7478	June 22	June 23	V.slight.	V.slight.	0.45	5.00	1.70	.0010	.0082	-	-	.53	.0250	.0000	1.4
7731	July 30	July 31	None.	V.slight, rusty.	0.30	5.25	0.90	.0062	.0026	-	-	.61	.0300	.0001	1.8
7847	Aug. 24	Aug. 25	V.slight.	V.slight.	0.25	6.00	1.10	.0020	.0080	-	-	.56	.0150	.0001	1.9
7969	Sept. 22	Sept. 23	Slight, milky.	Slight.	0.30	6.10	2.25	.0006	.0072	-	-	.56	.0050	.0000	1.7
8150	Oct. 21	Oct. 22	V.slight.	V.slight.	0.40	6.00	2.05	.0000	.0090	-	-	.60	.0150	.0002	1.8
8274	Nov. 23	Nov. 24	Slight.	Slight.	0.40	5.80	2.00	.0010	.0056	-	-	.67	.0200	.0001	1.7
8346	Dec. 17	Dec. 18	V.slight.	Cons.	0.40	5.55	1.50	.0004	.0086	.0052	.0034	.61	.0200	.0001	1.7
Av.	....	....	....	....	0.35	5.25	1.49	.0014	.0073	-	-	.55	.0212	.0000	1.7

Odor, generally vegetable, frequently grassy, occasionally none; often disappearing on heating.—— The samples were collected from a faucet at the pumping station while pumping. Water from the Taunton River is admitted directly to the filter-basin whenever the yield of the latter is insufficient for the supply of the city.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	28	28	26	23	31	25	23	22	24	18
Number of sample,	6948	7050	7146	7246	7344	7478	7731	7847	7969	8150	8274	8346
PLANTS.												
Diatomaceæ,	9	77	10	9	6	pr.	8	7	9	9	5	12
Diatoma,	0	0	0	2	2	0	0	0	5	0	0	0
Fragilaria,	0	0	7	0	0	0	0	0	0	0	0	4
Melosira,	2	74	2	2	4	0	5	3	1	2	1	4
Navicula,	1	3	pr.	2	0	pr	3	pr.	2	3	1	2
Synedra,	6	0	1	3	pr.	0	0	0	1	1	3	2
Tabellaria,	0	0	0	0	0	pr.	pr.	4	0	3	0	0

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ. Oscillaria,	0	0	3	5	3	3	0	1	0	11	2	0
Fungi. Crenothrix,	2	52	5	0	4	0	0	39	6	13	48	34
ANIMALS.												
Infusoria,	1	0	0	0	0	0	0	0	0	5	0	0
Dinobryon,	0	0	0	0	0	0	0	0	0	4	0	0
Peridinium,	1	0	0	0	0	0	0	0	0	1	0	0
Miscellaneous. Zoöglœa,	1	76	70	6	0	0	2	20	14	23	26	1
TOTAL,	13	205	88	20	13	3	10	67	29	61	81	47

Chemical Examination of Water from the Taunton River, at Taunton.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
6947	Jan. 26	Jan. 27	Slight.	Slight.	1.00	3.80	1.80	.0000	.0186	.0154	.0032	.32	.0120	.0001	0.9
7049	Feb. 24	Feb. 24	V. slight.	V. slight.	1.10	3.50	1.60	.0002	.0200	.0178	.0022	.30	.0150	.0001	0.6
7145	Mar. 26	Mar. 27	Slight.	Slight.	1.00	3.15	1.25	.0000	.0174	.0162	.0012	.32	.0100	.0001	0.8
7245	Apr. 27	Apr. 28	Slight.	Slight, rusty.	1.60	4.35	2.15	.0000	.0204	.0192	.0012	.41	.0100	.0000	0.8
7345	May 25	May 26	V. slight.	V. slight.	1.30	4.30	2.00	.0032	.0266	.0230	.0036	.35	.0080	.0000	0.6
7477	June 22	June 23	V. slight.	Slight.	1.20	5.15	1.90	.0024	.0228	.0212	.0016	.44	.0100	.0001	0.8
7730	July 30	July 31	V. slight.	Slight.	0.80	4.55	2.00	.0000	.0226	.0194	.0032	.52	.0050	.0000	0.9
7846	Aug. 24	Aug. 25	V. slight.	Slight.	0.70	4.30	1.45	.0000	.0190	.0166	.0024	.55	.0030	.0001	0.9
7968	Sept. 22	Sept. 23	V. slight.	V. slight.	1.00	5.45	2.40	.0006	.0240	.0226	.0014	.53	.0090	.0000	1.4
8149	Oct. 21	Oct. 22	V. slight.	Cons.	1.30	6.45	3.00	.0000	.0262	.0236	.0026	.62	.0100	.0002	1.4
8273	Nov. 23	Nov. 24	Slight.	Slight.	1.20	6.35	2.25	.0006	.0266	.0236	.0030	.74	.0130	.0000	1.3
8347	Dec. 17	Dec. 18	Slight.	Slight.	1.30	5.90	2.00	.0008	.0198	.0178	.0020	.59	.0090	.0003	1.1
Av.	....	....	....	....	1.12	4.77	1.98	.0006	.0220	.0197	.0023	.47	.0095	.0001	1.0

Odor, generally distinctly vegetable. —— The samples were collected from the river opposite the filter-basin of the Taunton water works.

TAUNTON.

Microscopical Examination of Water from the Taunton River at Taunton.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	28	28	26	23	31	25	23	22	24	18
Number of sample,	6947	7049	7145	7245	7345	7477	7780	7846	7968	8149	8273	8347
PLANTS.												
Diatomaceæ,	16	39	31	41	13	3	7	2	0	3	12	26
Asterionella,	0	0	5	8	0	0	0	0	0	0	1	6
Diatoma,	0	6	5	1	7	2	2	0	0	pr.	0	1
Melosira,	5	3	0	11	0	0	2	1	0	2	2	4
Meridion,	0	28	4	6	1	1	0	0	0	pr.	pr.	1
Navicula,	pr.	0	1	3	pr.	0	2	pr.	0	1	1	3
Synedra,	6	1	4	3	1	pr.	0	0	0	pr.	7	11
Tabellaria,	5	1	12	9	4	pr.	1	1	0	pr.	1	pr.
Cyanophyceæ. Chroöcoccus,	0	0	0	32	0	0	0	0	0	0	0	0
Algæ. Conferva,	0	0	0	8	0	pr.	0	0	0	0	0	0
Fungi. Crenothrix,	pr.	pr.	0	12	44	0	4	5	0	8	11	7
ANIMALS.												
Infusoria,	0	1	0	0	0	0	8	pr.	0	6	2	6
Dinobryon,	0	0	0	0	0	0	0	0	0	6	0	5
Monas,	0	0	0	0	0	0	2	0	0	0	0	1
Peridinium,	0	1	0	0	0	0	6	pr.	0	0	2	pr.
Miscellaneous. Zoöglœa,	92	244	274	112	8	2	5	0	17	114	82	18
TOTAL,	108	284	305	203	65	5	24	7	17	129	107	52

Chemical Examination of Water from Long, Assawompsett and Elder's Ponds in Lakeville, made during an Investigation for an additional Water Supply for Taunton.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1891.														
8313	Dec. 8	Dec. 9	V. slight.	V. slight.	0.60	2.95	1.70	.0000	.0108	.0096	.0012	.46	.0020	.0000	0.3
8357	Dec. 18	Dec. 19	V. slight.	Slight.	0.50	3.35	1.55	.0000	.0152	.0132	.0020	.51	.0020	.0001	0.2
8312	Dec. 8	Dec. 9	Slight.	Slight.	0.03	2.85	1.10	.0000	.0150	.0118	.0032	.46	.0020	.0000	0.5
8358	Dec. 18	Dec. 19	Slight.	Cons.	0.04	2.75	0.95	.0000	.0164	.0102	.0062	.47	.0030	.0000	0.3
8314	Dec. 8	Dec. 9	V. slight.	Slight.	0.00	2.05	1.15	.0000	.0162	.0138	.0024	.40	.0000	.0000	0.2
8359	Dec. 18	Dec. 19	V. slight.	Cons.	0.00	2.00	0.65	.0000	.0124	.0102	.0022	.40	.0020	.0001	0.3

Odor of Nos. 8313, 8312 and 8314, none; of the others, faintly vegetable.—— Samples Nos. 8313 and 8357 were collected from Long Pond, the former about 300 feet from shore and the latter near the boat landing and through the ice. Nos. 8312 and 8358 were collected from Assawompsett Pond not far from the shore. Nos. 8314 and 8359 were collected from Elder's Pond at the dam.

TAUNTON.

Microscopical Examination of Water from Long, Assawompsett and Elder's Ponds in Lakeville, made during an Investigation for an additional Water Supply for Taunton.

[Number of organisms per cubic centimeter.]

	1891.					
	Dec.	Dec.	Dec.	Dec.	Dec.	Dec.
Day of examination,	10	22	10	22	10	22
Number of sample,	8313	8357	8312	8358	8314	8359
PLANTS.						
Diatomaceæ,	**30**	**8**	**188**	**244**	**121**	**101**
Asterionella,	11	2	148	211	108	94
Cyclotella,	4	0	24	16	10	0
Diatoma,	4	0	4	0	0	0
Fragilaria,	0	0	3	2	0	0
Grammatophora,	2	0	0	0	0	0
Melosira,	4	0	6	0	0	0
Navicula,	1	1	1	2	0	2
Synedra,	4	1	1	1	3	3
Tabellaria,	0	4	1	12	0	2
Cyanophyceæ,	**4**	**16**	**11**	**14**	**16**	**31**
Anabæna,	0	0	0	0	0	3
Chroöcoccus,	4	16	11	12	0	13
Microcystis,	0	0	0	1	16	15
Oscillaria,	0	0	0	1	0	0
Algæ,	**4**	**48**	**13**	**5**	**54**	**17**
Chlorococcus,	4	48	12	4	0	0
Cosmarium,	0	0	0	0	15	3
Cœlastrum,	0	0	0	0	1	0
Desmidium,	0	0	0	0	0	3
Dictyosphærium,	0	0	0	0	0	2
Hyalotheca,	0	0	0	0	11	0
Pediastrum,	0	0	0	0	7	0
Raphidium,	0	0	0	0	0	5
Scenedesmus,	0	0	1	0	1	0
Staurastrum,	0	0	0	1	19	4
ANIMALS.						
Rhizopoda. Difflugia,	**0**	**0**	**1**	**0**	**0**	**0**
Infusoria,	**14**	**17**	**1**	**6**	**8**	**2**
Cryptomonas,	0	0	0	0	7	0
Dinobryon,	14	0	1	0	1	0
Dinobryon cases,	0	17	0	6	0	1
Peridinium,	0	0	0	0	0	1
Vermes. Anuræa,	**0**	**0**	**0**	**0**	**0**	**1**
Crustacea. Cyclops,	pr.	**0**	**0**	**0**	pr.	**0**
Miscellaneous. Zoöglœa,	**28**	**43**	**88**	**98**	**42**	**8**
TOTAL,	80	132	302	367	241	160

TEMPLETON.

Chemical Examination of Water from a Tubular Well at the Hospital Cottage for Children at Baldwinville, Templeton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8174	Oct. 28	Oct. 30	Decided.	Heavy. earthy.	0.0	7.45	.0000	.0006	.10	.0100	.0002	1.7

Odor, none.——The sample was collected after pumping for several hours. The well is 292 feet in depth.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 3,140.

Water Supply of Uxbridge.

The works of the Uxbridge Water Company were purchased by the town in 1890.

Water Supply of Wakefield and Stoneham. — Wakefield Water Company.

Chemical Examination of Water from Crystal Lake, Wakefield.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7290	May 6	May 7	V. slight.	None.	0.05	3.65	0.95	.0000	.0118	.0104	.0014	.45	.0220	.0001	1.7
8236	Nov. 9	Nov. 10	Slight.	Cons., green.	0.10	4.70	2.05	.0006	.0202	.0154	.0048	.49	.0070	.0000	1.4

Odor, vegetable and unpleasant.——The samples were collected from a faucet at the pumping station. The first sample was collected at a time when the pond was full; the second one at a time of very low water.

Microscopical Examination.

No. 7290. Diatomaceæ, *Asterionella*, 2; *Diatoma*, 3; *Melosira*, 1; *Navicula*, pr.; *Stephanodiscus*, 54; *Tabellaria*, 2. Infusoria, *Trachelomonas*, pr. Miscellaneous, *Zoöglœa*, 106. Total, 168.

No. 8236. Diatomaceæ, *Asterionella*, 2,688; *Cocconema*, pr.; *Epithemia*, pr.; *Fragilaria*, 166; *Melosira*, 6; *Stephanodiscus*, 38; *Tabellaria*, 3,512. Algæ, *Chlorococcus*, 8; *Staurastrum*, pr. Rhizopoda, *Actinophrys*, pr. Infusoria, *Monas*, pr. *Peridinium*, pr.; *Trachelomonas*, pr. Vermes, *Polyarthra*, pr. Miscellaneous, *Zoöglœa*, 43. Total, 6,461.

Water Supply of Waltham.

The capacity of the works was increased in 1891 by sinking a well 40 feet in diameter in the filter-basin to a depth of 18 feet below its bottom, and about 26.4 feet below the average level of the water in Charles River. The wall of the well is made of large split stones, laid without mortar, for a height of three feet above the bottom; and above this level of stone also laid without mortar with an interior lining 16 inches in thickness of brick masonry. The yield of the well during its construction is said to have been very large.

Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7341	May 21	May 22	Distinct.	Cons.	0.0	6.25	0.80	.0000	.0044	-	-	.40	.0200	.0000	3.0

Odor, faintly vegetable.——The sample was collected from the reservoir near its outlet. This sample and the two which follow were collected at a time when there was complaint of the taste and odor of the water.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 7,364; *Cyclotella*, 66; *Navicula*, 1; *Stephanodiscus*, 2 Algæ, *Chlorococcus*, 2; *Pediastrum*, 2; *Scenedesmus*, 1; *Sorastrum*, pr.; *Staurastrum*, pr.; *Zoöspores*, 16. Infusoria, *Dinobryon*, 14. Vermes, *Anurea*, pr.; *Synchæta*, 1. Miscellaneous, *Zoöglœa*, 260. Total, 7,729.

Chemical Examination of Water from Faucets in Waltham, supplied from the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7342	May 21	May 22	Slight.	Slight.	0.0	6.45	1.40	.0000	.0040	-	-	.40	.0250	.0000	3.0
7343	May 21	May 22	Slight.	Slight.	0.0	6.00	0.95	.0000	.0032	-	-	.41	.0250	.0000	3.0

Odor, distinctly vegetable.——The samples were collected from faucets in the city, No. 7342 from a dwelling-house at 797 Main Street, and No. 7343 from the works of the Waltham Watch Company.

Microscopical Examination.

No. 7342. Diatomaceæ, *Asterionella*, 4,992; *Navicula*, 1; *Synedra*, pr. Algæ, *Nephrocytium*, pr.; *Pediastrum*, 1; *Scenedesmus*, 1; *Sorastrum*, pr. Fungi, *Saccharomyces*, 68 Infusoria, *Dinobryon*, 6; *Peridinium*, 1; *Trachelomonas*, 2. Vermes, *Anurea*, pr. Total, 5,072.

No. 7343. Diatomaceæ, *Asterionella*, 5,888; *Cyclotella*, 11. Algæ, *Pediastrum*, 1; *Staurastrum*, pr.; *Tetraspora*, 2. Infusoria, *Monas*, pr. Miscellaneous, *Zoöglœa*, 76. Total, 5,978.

WARE.

WATER SUPPLY OF WARE.

Chemical Examination of Water from the Well of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
8207	Nov. 3	Nov. 4	None.	None.	0.00	11.70	.0000	.0000	1.44	.7000	.0000	3.9

Odor, none.——The sample was collected from a faucet at the pumping station while pumping.

Microscopical Examination.

Diatomaceæ, *Tabellaria*, 1. Fungi, *Crenothrix*, 1. Rhizopoda, *Difflugia*, pr. Miscellaneous, *Zoöglœa*, pr. Total, 2.

WATER SUPPLY OF WATERTOWN AND BELMONT. — WATERTOWN WATER SUPPLY COMPANY.

At the time these works were last described the source of supply was a filter-gallery, built in three sections, on the left bank of Charles River above Watertown. Since that time a system of tubular wells has been added near the pumping station, and a large well about 350 feet south-easterly from one section of the filter-gallery. There are 20 tubular wells, each 2½ inches in diameter and having an average depth of about 25 feet. Water is pumped from them into the filter-basin. The large well is 20 feet in diameter and 24 feet deep, and is covered with a roof to exclude the light. It is lined with stone up to a height of 15 feet above the bottom and the remainder of the wall is of brick masonry. It is connected with the filter-basin by a twelve-inch pipe.

Water Supply of Wayland.

Chemical Examination of Water from the Filter-gallery of the Wayland Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6866	Jan. 1	Jan. 2	Decided.	V. slight.	0.60	4.20	1.00	.0104	.0106	.0092	.0014	.28	.0500	.0001	2.2
6989	Feb. 4	Feb. 6	Distinct.	Cons.	0.15	3.90	0.90	.0074	.0054	-	-	.23	.0650	.0000	1.8
7057	Feb. 23	Feb. 25	Slight.	Cons.	0.30	4.00	0.95	.0116	.0066	.0040	.0026	.26	.0400	.0000	1.4
7153	Mar. 27	Mar. 28	Slight.	Much.	0.25	3.55	0.85	.0082	.0058	-	-	.28	.0600	.0000	1.6
7294	May 7	May 9	Distinct.	Cons., fibrous.	0.30	3.80	1.45	.0096	.0140	.0104	.0036	.24	.0110	.0000	1.4
7364	May 26	May 27	Distinct.	Cons.	0.35	3.55	1.60	.0130	.0140	.0118	.0022	.20	.0020	.0000	1.6
7525	June 30	July 2	Distinct, cloudy.	Cons., rusty.	0.30	3.85	1.20	.0174	.0140	.0120	.0020	.16	.0070	.0001	1.1
7754	Aug. 4	Aug. 7	Decided, milky.	Heavy, rusty.	0.45	3.45	0.95	.0180	.0162	.0116	.0046	.27	.0000	.0000	1.4
7947	Sept. 15	Sept. 17	Distinct, milky.	Cons., green.	0.60	4.30	1.35	.0204	.0164	.0130	.0034	.21	.0100	.0002	1.7
8159	Oct. 20	Oct. 22	Decided, milky.	Cons., rusty.	0.40	4.25	1.50	.0196	.0144	.0086	.0058	.25	.0090	.0001	1.4
8280	Nov. 28	Nov. 30	Decided.	Cons.	0.20	3.85	1.75	.0106	.0162	.0116	.0046	.29	.0120	.0000	1.6
8375	Dec. 30	Dec. 31	V. slight.	Cons., white.	0.50	4.55	1.10	.0052	.0116	.0098	.0018	.31	.0320	.0001	1.6
Av.	....	....	....	....	0.37	3.94	1.22	.0126	.0121	*.0102	*.0032	.25	.0248	.0000	1.6

Odor, generally none, occasionally faintly vegetable.——The samples were collected from a faucet in the gate-house supplied from the filter-gallery.

* Average for 10 months only.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	1891. Feb.	1891. Feb.	1891. Mar.	1891. May.	1891. May.	1891. July.	1891. Aug.	1891. Sept.	1891. Oct.	1891. Dec.	1892. Jan.
Day of examination, . .	3	6	26	31	13	28	3	6	18	23	1	2
Number of sample, . .	6866	6989	7057	7153	7294	7364	7525	7754	7947	8159	8280	8375
PLANTS.												
Diatomaceæ, . .	0	0	0	0	14	6	0	41	28	92	1	0
Melosira, . . .	0	0	0	0	8	5	0	41	28	92	0	0
Navicula, . . .	0	0	0	0	6	1	0	0	0	0	1	0
Cyanophyceæ, Chroöcoccus, . .	0	0	0	0	0	6	0	0	0	0	0	0

WAYLAND.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											1892.
	Jan.	Feb.	Feb.	Mar.	May.	May.	July.	Aug.	Sept.	Oct.	Dec.	Jan.
PLANTS — Con.												
Algæ,	0	0	0	0	2	5	8	29	0	4	0	0
Chlorococcus,	0	0	0	0	0	0	8	25	0	0	0	0
Pediastrum,	0	0	0	0	0	0	0	4	0	2	0	0
Scenedesmus,	0	0	0	0	2	5	0	0	0	2	0	0
Fungi. Crenothrix,	18,880	11,136	6,208	1,960	14,008	11,360	3,130	26,500	28,592	34,280	31,568	7,800
ANIMALS.												
Infusoria,	12	0	0	0	16	8	0	0	0	2	2	0
Dinobryon,	12	0	0	0	16	8	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	0	0	2	2	0
Miscellaneous. Zoöglœa,	0	0	0	0	0	0	172	686	0	0	0	2
TOTAL,	18,892	11,136	6,208	1,960	14,040	11,385	3,310	27,256	28,620	34,378	31,571	7,802

Chemical Examination of Water from the Storage Reservoir of the Wayland Water Works.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
6865	Jan. 1	Jan. 2	V. slight.	V. slight.	0.90	4.00	1.35	.0042	.0180	.0176	.0004	.25	.0300	.0001	1.7
6988	Feb. 4	Feb. 6	V. slight.	Slight.	0.70	3.35	1.10	.0012	.0140	.0106	.0034	.13	.0300	.0000	1.3
7056	Feb. 23	Feb. 25	V. slight.	None.	0.55	2.80	1.00	.0004	.0100	-	-	.13	.0150	.0000	0.9
7152	Mar. 27	Mar. 28	V. slight.	V. slight	0.40	2.70	1.70	.0002	.0118	.0098	.0020	.13	.0070	.0000	0.8
7293	May 7	May 9	Slight.	Slight, rusty.	0.60	3.20	1.60	.0010	.0220	.0174	.0046	.19	.0100	.0000	1.1
7365	May 26	May 27	Slight.	Slight.	0.65	3.85	2.10	.0008	.0266	.0176	.0090	.15	.0050	.0001	0.9
7524	June 30	July 2	Slight.	Slight.	0.80	3.85	1.90	.0022	.0248	.0230	.0018	.16	.0020	.0001	1.3
7753	Aug. 4	Aug. 7	Slight.	Slight.	0.40	4.00	1.80	.0016	.0316	.0246	.0070	.27	.0020	.0000	1.4
7948	Sept. 15	Sept. 17	Distinct.	Cons., green.	0.65	4.40	1.85	.0002	.0398	.0272	.0126	.22	.0150	.0001	1.4
8160	Oct. 20	Oct. 22	Distinct.	Cons., rusty.	0.60	4.65	1.80	.0090	.0332	.0208	.0124	.23	.0100	.0000	1.7
8279	Nov. 28	Nov. 30	Slight.	Slight.	0.85	3.50	1.10	.0046	.0342	.0216	.0126	.28	.0150	.0000	1.6
8376	Dec. 30	Dec 31	Slight.	Slight.	1.10	5.35	2.35	.0022	.0276	.0238	.0038	.26	.0090	.0001	1.4
Av.	....	....	....	....	0.68	3.80	1.64	.0023	.0258	.0195	.0063	.20	.0125	.0000	1.3

Odor, generally faintly vegetable or none, becoming stronger on heating. —— The samples were collected from the reservoir at the surface.

WAYLAND.

Microscopical Examination of Water from the Storage Reservoir of the Wayland Water Works.

[Number of organisms per cubic centimeter.]

	1891.											1892.
	Jan.	Feb.	Feb.	Mar	May.	May.	July.	Aug.	Sept.	Oct.	Dec.	Jan.
Day of examination,	3	6	26	28	13	28	3	5	18	23	1	2
Number of sample,	6865	6988	7056	7152	7293	7365	7524	7753	7948	8160	8279	8376
PLANTS.												
Diatomaceæ,	**6**	**2**	**36**	**81**	**422**	**102**	**9**	**95**	**343**	**336**	**179**	**163**
Asterionella,	3	0	pr.	11	47	11	0	23	0	35	4	8
Cyclotella,	0	0	0	0	1	0	0	4	0	0	3	1
Diatoma,	0	0	2	22	3	0	0	pr.	216	0	2	1
Melosira,	0	0	1	1	210	46	0	24	0	241	10	10
Meridion,	1	0	pr.	8	1	0	0	0	87	0	pr.	0
Navicula,	0	0	1	2	10	1	0	2	1	4	3	1
Synedra,	2	1	32	25	120	28	0	8	26	5	154	140
Tabellaria,	pr.	1	0	12	30	16	9	34	13	51	3	2
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**29**	**0**	**5**	**0**	**0**
Anabæna,	0	0	0	0	0	0	0	27	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	2	0	5	0	0
Algæ,	**0**	**0**	**0**	**pr.**	**29**	**4**	**20**	**335**	**759**	**64**	**0**	**pr.**
Chlorococcus,	0	0	0	0	13	4	13	332	28	56	0	0
Scenedesmus,	0	0	0	0	16	0	0	0	1	8	0	0
Staurastrum,	0	0	0	pr.	0	0	7	3	2	0	0	pr.
Zoöspores,	0	0	0	0	0	0	0	0	728	0	0	0
Fungi. Crenothrix,	**0**	**pr.**	**0**	**7**	**1**	**pr.**	**0**	**0**	**0**	**7**	**3**	**5**
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**0**	**0**	**1**	**4**	**23**	**0**	**5**	**pr.**	**0**
Actinophrys,	0	0	0	0	0	1	4	23	0	0	pr.	0
Difflugia,	0	0	0	0	0	0	0	0	0	5	0	0
Infusoria,	**7**	**1**	**2**	**5**	**230**	**398**	**24**	**34**	**31**	**5**	**6**	**pr.**
Dinobryon,	4	0	0	2	230	398	24	0	0	0	4	0
Dinobryon cases,	0	0	0	0	0	0	0	8	0	1	pr.	pr.
Monas,	0	0	0	2	0	0	0	1	0	0	1	0
Peridinium,	3	1	2	1	0	0	pr.	16	16	0	pr.	pr.
Trachelomonas,	0	0	0	pr.	0	0	0	4	15	4	1	pr.
Vorticella,	0	0	0	0	0	0	0	5	0	0	0	0
Vermes,	**0**	**0**	**0**	**pr.**	**0**	**5**	**0**	**4**	**1**	**2**	**pr.**	**pr.**
Anurea,	0	0	0	pr.	0	2	0	1	1	0	0	pr.
Polyarthra,	0	0	0	0	0	0	0	3	0	2	0	0
Rotatorian ova,	0	0	0	0	0	3	0	0	0	0	pr.	pr.
Crustacea,	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**pr.**	**0**	**0**	**0**
Cyclops,	0	0	0	0	0	0	pr.	pr.	pr.	0	0	0
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	**6**	**64**	**362**	**256**	**546**	**160**	**42**	**122**	**516**	**404**	**156**	**68**
TOTAL,	19	67	400	351	1,228	670	99	642	1,650	833	344	236

WESTBOROUGH.

Water Supply of Westborough.

Chemical Examination of Water from the Lower Basin, Sandra Pond, Westborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7507	June 30	July 1	V. slight.	V. slight.	0.05	2.85	1.15	.0002	.0124	.0106	.0018	.17	.0030	.0002	0.8

Odor, none.——The sample was collected from the lower basin at the surface.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2; *Stephanodiscus*, pr.; *Tabellaria*, 1. Algæ, *Chlorococcus*, 10; *Closterium*, 1; *Scenedesmus*, 1; *Staurastrum*, pr. Fungi, *Crenothrix*, pr. Infusoria, *Dinobryon*, 60; *Glenodinium*, 20. Vermes, *Anurea*, 1; *Rotatorian ova*, 1. Miscellaneous, *Zoöglœa*, 3. Total, 100.

Chemical Examination of Water from the Upper Basin, Sandra Pond, Westborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7506	June 30	July 1	Slight.	Slight.	0.25	2.50	1.15	.0000	.0206	.0152	.0054	.14	.0050	.0001	0.6

Odor, vegetable and unpleasant.——The sample was collected from the pond at the surface.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 8; *Cyclotella*, 1; *Diatoma*, 2; *Synedra*, 238; *Tabellaria*, 3. Cyanophyceæ, *Anabæna*, 12. Algæ, *Chlorococcus*, 18; *Pediastrum*, 1; *Scenedesmus*, 1; *Staurastrum*, 19. Infusoria, *Dinobryon*, 16; *Glenodinium*, 29. Vermes, *Sacculus*, pr. Crustacea, *Cyclops*, pr. Miscellaneous, *Zoöglœa*, 5. Total, 353.

WESTBOROUGH.

WATER SUPPLY OF WESTBOROUGH INSANE HOSPITAL, WESTBOROUGH.

Chemical Examination of Water from the Tubular Wells of the Westborough Insane Hospital.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.	
	1891.											
7566	July 18	July 20	Slight, milky.	Slight, white.	0.50	11.70	.0768	.0104	.43	.0040	.0000	6.0
7567	July 18	July 20	Slight, milky.	V. slight, white.	0.50	11.90	.0800	.0114	.42	.0040	.0000	5.9
7568	July 18	July 20	Distinct, milky.	Heavy, yellow.	0.50	12.10	.0720	.0140	.41	.0050	.0005	5.9
7569	July 18	July 20	Distinct.	Cons., yellow.	0.50	7.40	.0672	.0138	.42	.0070	.0000	5.9

Odor of Nos. 7566 and 7569, mouldy and unpleasant; of the others, faintly mouldy.——No. 7566 was collected from the line of tubular wells very near the shore of Chauncy Pond; No. 7567, from the line of tubular wells in the meadow at some distance from the pond; No. 7568, from a faucet in the laundry in the main building; No. 7569, from a faucet in the farm barn, which is the most distant point supplied with water from this source.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891.			
	July.	July.	July.	July.
Day of examination,	20	20	20	20
Number of sample,	7566	7567	7568	7569
PLANTS.				
Diatomaceæ. Melosira,	0	0	3	0
Fungi. Crenothrix,	0	0	101	79
Miscellaneous. Zoöglœa,	57	66	476	149
TOTAL,	57	66	580	228

WEST BOYLSTON.

West Boylston.

Chemical Examination of Water from Malden and Trout Brooks, made during an Investigation for a Water Supply for West Boylston.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8351	Dec. 18	Dec. 19	None.	None.	1.3	5.90	2.60	.0000	.0194	.0178	.0016	.21	.0090	.0000	1.3
8370	Dec. 28	Dec. 29	None.	V. slight.	1.5	5.15	2.70	.0000	.0152	.0124	.0028	.18	.0120	.0000	0.6

Odor of No. 8351, none; of No. 8370, faintly vegetable. —— Sample No. 8351 was collected from Malden Brook near the point where it has been suggested a storage reservoir might be built to supply the town by gravity. No. 8370 was collected from Trout Brook in Holden at the first road crossing above its mouth.

Microscopical Examination.

No. 8351. Diatomaceæ, *Melosira*, 3; *Tabellaria*, 2. Algæ, *Closterium*, 2. Infusoria, *Dinobryon*, 4; *Peridinium cases*, 1. Miscellaneous, *Zoöglœa*, 3. Total, 15.

No. 8370. Diatomaceæ, *Melosira*, 1; *Navicula*, 2; *Nitzschia*, 3; *Synedra*, 6; *Tabellaria*, 2. Algæ, *Raphidium*, 2. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglœa*, 6. Total, 23.

Water Supply of Westfield.

Chemical Examination of Water from the Distributing Reservoir of the Westfield Water Works, and from a Hydrant.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7496	June 26	June 27	Distinct.	Cons.	0.35	2.60	0.95	.0018	.0246	.0166	.0080	.08	.0030	.0002	0.5
7728	July 30	July 31	Decided, clayey.	Cons.	0.40	2.80	1.10	.0000	.0254	.0130	.0124	.16	.0150	.0000	0.4
7842	Aug. 20	Aug. 21	Distinct	Cons., rusty.	0.60	3.75	1.35	.0000	.0230	.0126	.0104	.10	.0100	.0001	0.3
7963	Sept. 20	Sept. 22	Slight.	Slight, green.	0.60	3.35	1.55	.0010	.0244	.0180	.0064	.09	.0000	.0000	0.5
8182	Oct. 30	Nov. 2	V. slight.	Slight.	0.80	3.25	1.40	.0014	.0198	.0150	.0048	.14	.0050	.0000	0.3
Av.	....	....	....	....	0.55	3.15	1.27	.0008	.0234	.0150	.0084	.11	.0066	.0001	0.4

Odor, none, excepting in October, when it was faintly vegetable; on heating, vegetable; sometimes mouldy. —— Nos. 7728 and 7842 were collected from a hydrant in the town; the others were collected from the distributing reservoir.

WESTFIELD.

Microscopical Examination of Water from the Distributing Reservoir of the Westfield Water Works and from a Hydrant.

[Number of organisms per cubic centimeter.]

	1891.				
	June.	July.	Aug.	Sept.	Nov.
Day of examination,	29	31	21	22	1
Number of sample,	7496	7728	7842	7963	8182
PLANTS.					
Diatomaceæ,	**20**	**354**	**180**	**44**	**14**
Asterionella,	0	22	0	16	1
Cocconeis,	0	7	0	0	0
Diatoma,	0	0	0	4	0
Melosira,	0	17	4	0	0
Navicula,	0	50	0	0	pr.
Navicula cases,	0	0	82	0	0
Stephanodiscus,	0	3	0	0	0
Synedra,	pr.	15	0	11	pr.
Tabellaria,	20	240	0	13	13
Tabellaria cases,	0	0	74	0	0
Cyanophyceæ,	**39**	**0**	**0**	**3**	**0**
Anabæna,	39	0	0	0	0
Chroöcoccus,	0	0	0	3	0
Algæ,	**16**	**8**	**0**	**94**	**3**
Chlorococcus,	16	0	0	90	3
Merismopedia,	0	0	0	4	0
Scenedesmus,	0	3	0	0	0
Staurastrum,	0	5	0	0	0
Fungi,	**3**	**80**	**12**	**30**	**14**
Beggiatoa,	0	0	3	0	0
Crenothrix,	3	80	9	30	10
Molds,	0	0	0	0	4
ANIMALS.					
Infusoria,	**3**	**207**	**9**	**16**	**5**
Ceratium,	2	0	0	0	0
Dinobryon,	0	0	0	12	4
Euglena,	0	2	pr.	0	0
Monas,	0	0	2	2	pr.
Peridinium,	1	205	0	2	0
Peridinium cases,	0	0	3	0	0
Trachelomonas,	0	0	4	pr.	1
Vermes. Rotifer,	**0**	**0**	**0**	**2**	**0**
Miscellaneous. Zoöglœa,	**132**	**670**	**272**	**398**	**15**
TOTAL,	213	1,319	453	587	51

WESTMINSTER.

For analyses of water from Meeting-house and Wachusett ponds, and from streams near them, see *Fitchburg*.

WATER SUPPLY OF WHITMAN.

A tubular well 6 inches in diameter and 227 feet deep has been added to the former sources of supply.

Chemical Examination of Water from the Filter-gallery of the Whitman Water Works.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
6951	Jan. 26	Jan. 27	Distinct, milky.	V. slight.	0.45	3.70	1.45	.0002	.0224	-	-	.50	.0180	.0001	1.1
7052	Feb. 24	Feb. 25	V. slight.	V. slight.	0.25	4.05	1.25	.0032	.0076	-	-	.47	.0200	.0000	1.7
7139	Mar. 20	Mar. 21	Slight.	Slight.	0.35	3.70	1.10	.0000	.0118	-	-	.48	.0300	.0001	1.7
7251	Apr. 28	Apr. 29	Decided, clayey.	V. slight.	0.25	4.50	1.00	.0094	.0090	.0080	.0010	.65	.0150	.0000	1.7
7398	June 5	June 6	Decided.	Heavy.	0.25	6.50	1.90	.0156	.0216	.0172	.0044	.74	.0150	.0002	1.8
7475	June 22	June 23	Decided.	Cons.	1.00	6.40	-	.0138	.0242	-	-	.65	.0070	.0003	1.9
7734	July 30	July 31	Distinct, milky.	Cons., yellow.	0.65	7.10	-	.0086	.0216	-	-	.67	.0090	.0000	1.9
7853	Aug. 24	Aug. 25	Slight.	Cons.	0.45	6.35	2.55	.0018	.0374	-	-	.76	.0030	.0001	1.8
7967	Sept. 22	Sept. 23	Slight.	Slight.	0.75	5.75	-	.0018	.0316	-	-	.72	.0070	.0000	1.7
8152	Oct. 21	Oct. 22	Decided, milky.	Slight.	0.55	6.40	-	.0140	.0134	-	-	.76	.0100	.0001	2.6
8265	Nov. 17	Nov. 17	Slight.	Slight.	0.23	6.40	1.35	.0056	.0154	.0138	.0016	.90	.0150	.0000	2.2
8340	Dec. 16	Dec. 17	Distinct, milky.	Cons.	0.28	6.80	1.10	.0060	.0048	-	-	.83	.0150	.0003	2.6
Av.	....	....	....	....	0.45	5.64	1.46	.0067	.0184	-	-	.68	.0137	.0001	1.9

Odor, faintly vegetable or none; occasionally mouldy; when heated, generally stronger; frequently mouldy and occasionally unpleasant or disagreeable.—— The samples were collected from the filter-gallery. During the summer and autumn it is sometimes necessary to draw water directly from Hobart's Pond, as the supply from the filter-gallery alone is not sufficient for the use of the town.

WHITMAN.

Microscopical Examination of Water from the Filter-gallery of the Whitman Water Works.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	21	29	6	23	31	25	23	22	18	17
Number of sample,	6951	7052	7139	7251	7398	7475	7734	7853	7967	8152	8265	8340
PLANTS.												
Diatomaceæ,	**13**	**12**	**31**	**0**	**0**	**0**	**20**	**11**	**13**	**0**	**3**	**2**
Cyclotella,	0	0	0	0	0	0	10	0	0	0	0	0
Diatoma,	0	0	15	0	0	0	5	0	2	0	0	0
Synedra,	13	12	14	0	0	0	5	2	11	0	3	2
Tabellaria,	0	0	2	0	0	0	0	9	0	0	0	0
Cyanophyceæ. Chroöcoccus,	**0**	**0**	**0**	**0**	**0**	**0**	**45**	**10**	**0**	**0**	**0**	**0**
Algæ,	**pr.**	**1**	**12**	**0**	**0**	**0**	**38**	**43**	**29**	**1**	**0**	**0**
Chlorococcus,	0	1	0	0	0	0	12	32	26	1	0	0
Protococcus,	0	0	0	0	0	0	10	0	0	0	0	0
Raphidium,	0	0	0	0	0	0	3	7	0	0	0	0
Scenedesmus,	pr.	0	0	0	0	0	5	0	pr.	0	0	0
Sorastrum,	0	0	0	0	0	0	8	0	0	0	0	0
Staurastrum,	pr.	0	0	0	0	0	0	4	1	0	0	0
Zoöspores,	0	0	12	0	0	0	0	0	2	0	0	0
Fungi. Crenothrix,	**0**	**6**	**17**	**0**	**4,640**	**26**	**3,196**	**1**	**6**	**172**	**0**	**536**
ANIMALS.												
Infusoria,	**3**	**1**	**56**	**0**	**0**	**0**	**49**	**48**	**89**	**0**	**5**	**0**
Dinobryon,	1	0	14	0	0	0	4	14	0	0	3	0
Dinobryon cases,	0	0	0	0	0	0	0	0	86	0	0	0
Euglena,	0	0	0	0	0	0	3	0	0	0	0	0
Monas,	0	0	0	0	0	0	14	1	0	0	pr.	0
Peridinium,	2	1	0	0	0	0	21	31	0	0	0	0
Synura,	0	0	42	0	0	0	0	0	0	0	1	0
Trachelomonas,	0	0	0	0	0	0	7	2	3	0	1	0
Crustacea,	**pr.**	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**pr.**	**pr.**	**pr.**	**pr.**	**0**
Bosmina,	0	0	0	0	0	0	pr.	0	0	0	0	0
Cyclops,	pr.	0	0	0	0	pr.	0	pr.	pr.	pr.	pr.	0
Miscellaneous. Zoöglœa,	**22**	**72**	**14**	**36**	**23**	**452**	**4**	**4**	**776**	**334**	**0**	**4**
TOTAL,	38	92	130	36	4,663	478	3,352	117	913	507	8	542

WHITMAN.

Chemical Examination of Water from Hobart's Pond in Whitman.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6952	Jan. 26	Jan. 27	Slight, milky.	None.	0.40	3.55	1.40	.0010	.0130	.0118	.0012	.41	.0380	.0002	0.9
7051	Feb. 24	Feb. 25	Slight.	V. slight.	0.40	3.75	1.30	.0002	.0212	.0152	.0060	.42	.0210	.0001	1.4
7138	Mar. 20	Mar. 21	Slight.	V. slight.	0.35	3.70	1.30	.0000	.0156	.0132	.0024	.49	.0200	.0001	1.4
7250	Apr. 28	Apr. 29	Distinct.	Cons.	0.80	5.15	1.80	.0028	.0430	.0334	.0096	.64	.0250	.0001	1.8
7355	May 25	May 26	Slight.	V. slight.	0.70	6.55	2.55	.0012	.0436	.0370	.0066	.78	.0050	.0000	1.8
7476	June 22	June 23	Slight.	Slight.	0.90	6.45	1.95	.0016	.0458	.0372	.0086	.65	.0030	.0000	1.8
7733	July 30	July 31	Distinct.	Cons.	0.70	5.55	2.15	.0014	.0430	.0354	.0076	.61	.0070	.0000	1.6
7852	Aug. 24	Aug. 25	Distinct.	Slight.	0.45	5.35	2.00	.0004	.0396	.0318	.0078	.69	.0000	.0003	1.7
7966	Sept. 21	Sept. 23	Distinct.	Slight.	0.55	5.50	2.35	.0016	.0396	.0316	.0080	.70	.0050	.0000	1.6
8151	Oct. 21	Oct. 22	Distinct.	Cons.	0.50	5.55	2.00	.0008	.0388	.0344	.0044	.81	.0000	.0001	1.7
8264	Nov. 17	Nov. 17	Slight.	Cons.	0.90	6.40	2.60	.0030	.0344	.0272	.0072	1.04	.0020	.0000	1.6
8339	Dec. 16	Dec. 17	Slight.	Slight.	1.00	6.55	2.80	.0010	.0232	.0200	.0032	.91	.0090	.0004	1.4
Av.	....	....	....	....	0.64	5.34	2.02	.0012	.0334	.0273	.0061	.68	.0112	.0001	1.6

Odor, generally vegetable, occasionally mouldy, sometimes none; on heating, the odor becomes stronger and is frequently mouldy and disagreeable or unpleasant. —— The samples were collected from the pond near the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	21	29	27	23	31	25	23	22	18	17
Number of sample,	6952	7051	7138	7250	7355	7476	7733	7852	7966	8151	8264	8339
PLANTS.												
Diatomaceæ,	**1**	**10**	**22**	**45**	**52**	**15**	**149**	**26**	**56**	**24**	**88**	**108**
Asterionella,	0	0	0	6	3	0	0	0	0	0	0	0
Cyclotella,	0	0	0	0	0	3	2	0	0	2	4	0
Diatoma,	0	7	6	2	1	1	1	5	9	pr.	2	6
Fragilaria,	0	0	0	5	0	0	13	0	0	2	1	4
Melosira,	0	2	0	6	0	0	8	0	2	1	0	4
Navicula,	0	0	pr.	6	2	0	8	0	1	1	1	pr.
Synedra,	1	1	16	14	46	6	49	1	44	9	80	94
Tabellaria,	pr.	0	pr.	6	0	5	68	20	0	9	0	0
Cyanophyceæ. Chroöcoccus,	**0**	**4**	**0**	**4**	**5**	**12**	**18**	**39**	**0**	**14**	**0**	**0**

WHITMAN.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	**0**	**55**	**23**	**41**	**85**	**46**	**383**	**63**	**109**	**62**	**7**	**pr.**
Chlorococcus,	0	54	10	0	16	22	354	19	84	56	0	0
Closterium,	0	0	1	0	4	3	1	0	0	0	pr.	0
Cosmarium,	0	0	0	0	1	0	4	1	0	pr.	0	0
Pandorina,	0	0	0	1	1	17	1	21	0	0	0	pr.
Raphidium,	0	0	0	2	0	0	3	0	1	3	6	0
Scenedesmus,	0	0	0	2	3	1	11	1	2	1	1	pr.
Staurastrum,	0	0	0	2	60	2	6	9	8	2	pr.	0
Zoöspores,	0	1	12	34	0	1	3	12	14	0	0	0
Fungi. Crenothrix,	**1**	**24**	**23**	**70**	**20**	**74**	**23**	**pr.**	**28**	**4**	**34**	**3**
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**pr.**	**2**	**4**	**0**	**0**	**1**	**pr.**	**1**
Infusoria,	**9**	**89**	**60**	**284**	**477**	**5**	**170**	**70**	**265**	**663**	**25**	**298**
Dinobryon,	0	88	22	248	464	0	0	15	128	580	20	172
Dinobryon cases,	0	0	0	0	0	0	10	0	0	62	pr.	124
Monas,	0	0	2	2	0	4	4	1	2	pr.	0	pr.
Peridinium,	9	1	2	2	1	0	130	50	132	20	pr.	0
Synura,	0	0	34	0	0	0	0	0	0	0	5	2
Trachelomonas,	0	0	0	2	12	1	24	4	3	1	pr.	0
Uvella,	0	0	0	30	0	0	0	0	0	0	0	0
Vermes. Anurea,	**0**	**0**	**0**	**0**	**0**	**1**	**4**	**1**	**1**	**pr.**	**1**	**pr.**
Crustacea,	**0**	**0**	**0**	**pr.**	**0**	**0**	**pr.**	**0**	**pr.**	**pr.**	**0**	**0**
Bosmina,	0	0	0	pr.	0	0	pr.	0	pr.	0	0	0
Cyclops,	0	0	0	0	0	0	pr.	0	pr.	pr.	0	0
Miscellaneous. Zoöglœa,	**6**	**142**	**18**	**524**	**400**	**236**	**380**	**102**	**604**	**160**	**28**	**0**
TOTAL,	17	324	146	968	1,039	391	1,131	301	1,063	928	183	410

Chemical Examination of Water from the Deep Tubular Well at Whitman.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7356	May 25	May 26	Distinct, milky.	None.	0.10	11.50	.0014	.0030	.60	.0100	.0000	5.1

Odor, none. —— The sample was collected from the well.

Microscopical Examination.

Infusoria, *Trachelomonas*, pr. Miscellaneous, *Zoöglœa*, 32. Total, 32.

WHITMAN.

Chemical Examination of Water from Hobart's Pond in Whitman.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
6952	Jan. 26	Jan. 27	Slight, milky.	None.	0.40	3.55	1.40	.0010	.0130	.0118	.0012	.41	.0380	.0002	0.9
7051	Feb. 24	Feb. 25	Slight.	V. slight.	0.40	3.75	1.30	.0002	.0212	.0152	.0060	.42	.0210	.0001	1.4
7138	Mar. 20	Mar. 21	Slight.	V. slight.	0.35	3.70	1.30	.0000	.0156	.0132	.0024	.49	.0200	.0001	1.4
7250	Apr. 28	Apr. 29	Distinct.	Cons.	0.80	5.15	1.80	.0028	.0430	.0334	.0096	.64	.0250	.0001	1.8
7355	May 25	May 26	Slight.	V. slight.	0.70	6.55	2.55	.0012	.0436	.0370	.0066	.78	.0050	.0000	1.8
7476	June 22	June 23	Slight.	Slight.	0.90	6.45	1.95	.0016	.0458	.0372	.0086	.65	.0030	.0000	1.8
7733	July 30	July 31	Distinct.	Cons.	0.70	5.55	2.15	.0014	.0430	.0354	.0076	.61	.0070	.0000	1.6
7852	Aug. 24	Aug. 25	Distinct.	Slight.	0.45	5.35	2.00	.0004	.0396	.0318	.0078	.69	.0000	.0003	1.7
7966	Sept. 21	Sept. 23	Distinct.	Slight.	0.55	5.50	2.35	.0016	.0396	.0316	.0080	.70	.0050	.0000	1.6
8151	Oct. 21	Oct. 22	Distinct.	Cons.	0.50	5.55	2.00	.0008	.0388	.0344	.0044	.81	.0000	.0001	1.7
8264	Nov. 17	Nov. 17	Slight.	Cons.	0.90	6.40	2.60	.0030	.0344	.0272	.0072	1.04	.0020	.0000	1.6
8339	Dec. 16	Dec. 17	Slight.	Slight.	1.00	6.55	2.80	.0010	.0232	.0200	.0032	.91	.0090	.0004	1.4
Av.	....	....	....	....	0.64	5.34	2.02	.0012	.0334	.0273	.0061	.68	.0112	.0001	1.6

Odor, generally vegetable, occasionally mouldy, sometimes none; on heating, the odor becomes stronger and is frequently mouldy and disagreeable or unpleasant.——The samples were collected from the pond near the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	26	21	29	27	23	31	25	23	22	18	17
Number of sample,	6952	7051	7138	7250	7355	7476	7733	7852	7966	8151	8264	8339
PLANTS.												
Diatomaceæ,	**1**	**10**	**22**	**45**	**52**	**15**	**149**	**26**	**56**	**24**	**88**	**108**
Asterionella,	0	0	0	6	3	0	0	0	0	0	0	0
Cyclotella,	0	0	0	0	0	3	2	0	0	2	4	0
Diatoma,	0	7	6	2	1	1	1	5	9	pr.	2	6
Fragilaria,	0	0	0	5	0	0	13	0	0	2	1	4
Melosira,	0	2	0	6	0	0	8	0	2	1	0	4
Navicula,	0	0	pr.	6	2	0	8	0	1	1	1	pr.
Synedra,	1	1	16	14	46	6	49	1	44	9	80	94
Tabellaria,	pr.	0	pr.	6	0	5	68	20	0	9	0	0
Cyanophyceæ. Chroöcoccus,	**0**	**4**	**0**	**4**	**5**	**12**	**18**	**39**	**0**	**14**	**0**	**0**

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	0	55	23	41	85	46	383	63	109	62	7	pr.
Chlorococcus,	0	54	10	0	16	22	354	19	84	56	0	0
Closterium,	0	0	1	0	4	3	1	0	0	0	pr.	0
Cosmarium,	0	0	0	0	1	0	4	1	0	pr.	0	0
Pandorina,	0	0	0	1	1	17	1	21	0	0	0	pr.
Raphidium,	0	0	0	2	0	0	3	0	1	3	6	0
Scenedesmus,	0	0	0	2	3	1	11	1	2	1	1	pr.
Staurastrum,	0	0	0	2	60	2	6	9	8	2	pr.	0
Zoöspores,	0	1	12	34	0	1	3	12	14	0	0	0
Fungi. Crenothrix,	1	24	23	70	20	74	23	pr.	28	4	34	3
ANIMALS.												
Rhizopoda. Actinophrys,	0	0	0	0	pr.	2	4	0	0	1	pr.	1
Infusoria,	9	89	60	284	477	5	170	70	265	663	25	298
Dinobryon,	0	88	22	248	464	0	0	15	128	580	20	172
Dinobryon cases,	0	0	0	0	0	0	10	0	0	62	pr.	124
Monas,	0	0	2	2	0	4	4	1	2	pr.	0	pr.
Peridinium,	9	1	2	2	1	0	130	50	132	20	pr.	0
Synura,	0	0	34	0	0	0	0	0	0	0	5	2
Trachelomonas,	0	0	0	2	12	1	24	4	3	1	pr.	0
Uvella,	0	0	0	30	0	0	0	0	0	0	0	0
Vermes. Anurea,	0	0	0	0	0	1	4	1	1	pr.	1	pr.
Crustacea,	0	0	0	pr.	0	0	pr.	0	pr.	pr.	0	0
Bosmina,	0	0	0	pr.	0	0	pr.	0	pr.	0	0	0
Cyclops,	0	0	0	0	0	0	pr.	0	pr.	pr.	0	0
Miscellaneous. Zoöglœa,	6	142	18	524	400	236	380	102	604	160	28	0
TOTAL,	17	324	146	968	1,039	391	1,131	301	1,063	928	183	410

Chemical Examination of Water from the Deep Tubular Well at Whitman.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.	
	1891.											
7356	May 25	May 26	Distinct, milky.	None.	0.10	11.50	.0014	.0030	.60	.0100	.0000	5.1

Odor, none. —— The sample was collected from the well.

Microscopical Examination.

Infusoria, *Trachelomonas*, pr. Miscellaneous, *Zoöglœa*, 32. Total, 32.

WINCHESTER.

Water Supply of Winchester.

The South Reservoir, the construction of which was begun in 1881 and subsequently discontinued, was completed in 1891. It is situated but a short distance south of the North Reservoir, which is now used to supply the town, but it is not connected with it, as there is a narrow ridge between the upper ends of the two reservoirs. The new reservoir covers an area of about 160 acres, and has a water-shed, exclusive of the water surface, of 385 acres. The reservoir is separated into two parts by a dam, crossing a narrow portion, about midway between its upper and lower ends. The lower division has an area of 100 acres, very bold shores to a depth of 20 feet or more below high-water mark, and a maximum depth of about 40 feet just above the dam. The upper division floods an extensive swamp to a depth of about 13 feet. The water in the upper division can be raised three feet higher than in the lower one. A twenty-four-inch pipe, provided with a gate, is laid through the dam, by which water can be drawn from the upper division into the lower one, and an overflow is also provided. This reservoir has a very large capacity in proportion to its water-shed, so that it requires more than a year to fill. It is not yet filled, nor is it connected with the pipe system in the town.

Chemical Examination of Water from Dike's Meadow Brook at the Point where it enters the North Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1891.														
6976	Feb. 3	Feb. 4	V.slight.	Slight.	0.40	7.40	1.90	.0402	.0192	.0152	.0040	.62	.1000	.0007	3.1
7091	Mar. 3	Mar. 6	Slight.	V.slight.	0.10	3.40	1.10	.0092	.0136	.0120	.0016	.54	.0250	.0002	1.4
7224	Apr. 20	Apr. 21	Slight.	Slight.	0.40	7.10	2.10	.0066	.0148	.0118	.0030	.59	.0600	.0025	3.3
7379	June 1	June 2	Distinct.	Cons.	0.70	8.10	1.50	.0064	.0238	.0224	.0014	.62	.0020	.0000	3.8
7522	July 1	July 2	V.slight.	Slight.	0.25	8.35	1.60	.0062	.0178	.0158	.0020	.60	.0070	.0008	3.8
7907	Sept. 9	Sept. 9	Slight.	Slight.	1.00	11.85	3.75	.0078	.0420	.0388	.0032	.67	.0280	.0002	4.2
8201	Nov. 3	Nov. 4	V.slight.	V.slight.	0.30	10.60	2.25	.0000	.0220	.0202	.0018	.81	.0100	.0000	4.0
Av.	....	....	....	....	0.45	8.11	2.03	.0109	.0219	.0195	.0024	.64	.0331	.0006	3.4

Odor, generally faintly vegetable, sometimes none.——Nos. 7091 and 7379 were distinctly vegetable, becoming strongly vegetable and disagreeable on heating.

WINCHESTER.

Microscopical Examination of Water from Dike's Meadow Brook at the Point where it enters the North Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1891.						
	Feb.	March.	April.	June.	July.	Sept.	Nov.
Date of examination,	5	7	21	3	2	10	4
Number of sample,	6976	7091	7224	7379	7522	7907	8201
PLANTS.							
Diatomaceæ,	25	956	21	9	1	pr.	23
Asterionella,	pr.	904	0	0	0	0	2
Melosira,	4	0	0	0	0	0	0
Navicula,	3	0	0	2	1	pr.	20
Pinnularia,	1	0	1	2	0	0	0
Stephanodiscus,	8	52	0	0	0	0	0
Synedra,	1	0	20	2	0	0	1
Tabellaria,	8	0	0	3	0	0	pr.
Algæ,	pr.	86	53	7	45	6	1
Chlorococcus,	0	0	1	1	45	0	0
Pleurococcus,	0	86	0	0	0	0	0
Scenedesmus,	0	0	0	6	0	0	1
Sphærozosma,	0	0	0	0	0	6	0
Zoöspores,	pr.	0	52	0	0	0	0
Fungi,	0	pr.	16	128	110	214	3
Cladothrix,	0	0	0	0	0	214	0
Crenothrix,	0	pr.	16	128	110	0	3
ANIMALS.							
Rhizopoda. Actinophrys,	0	0	0	0	0	1	0
Infusoria,	6	22	pr.	3	0	5	1
Dinobryon,	6	2	0	0	0	0	0
Encysted protozoön,	0	0	0	2	0	0	0
Glenodinium,	0	14	0	0	0	0	0
Monas,	0	0	0	0	0	2	0
Peridinium,	0	0	0	0	0	2	1
Trachelomonas,	0	6	pr.	1	0	1	pr.
Crustacea. Bosmina,	0	0	0	pr.	0	0	0
Miscellaneous. Zoöglœa,	200	6	708	356	16	296	22
TOTAL,	231	1,070	798	503	172	522	50

WINCHESTER.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6873	Jan. 5	Jan. 7	V. slight.	Cons.	0.10	5.45	1.30	.0022	.0194	.0180	.0014	.61	.0300	.0002	2.7
6977	Feb. 3	Feb. 4	Slight.	V. slight.	0.30	5.20	1.75	.0182	.0200	.0158	.0042	.47	.0400	.0005	2.2
7092	Mar. 3	Mar. 6	Slight.	V. slight.	0.10	3.90	1.35	.0032	.0174	.0098	.0076	.34	.0250	.0001	1.4
7173	Apr. 6	Apr. 7	Distinct.	Heavy, green.	0.15	5.35	1.95	.0006	.0262	.0148	.0114	.51	.0250	.0001	1.9
7174	Apr. 6	Apr. 7	Distinct.	Cons., green.	0.20	4.40	1.20	.0018	.0212	.0132	.0080	.49	.0250	.0001	1.9
7225	Apr. 20	Apr. 21	Slight.	Cons.	0.15	4.55	1.35	.0000	.0220	.0168	.0052	.54	.0250	.0002	2.3
7226	Apr 20	Apr. 21	Slight.	Cons.	0.10	-	-	.0008	.0228	.0158	.0070	-	.0250	.0002	-
7320	May 14	May 15	Distinct.	Slight, white.	0.10	4.60	1.65	.0026	.0250	.0176	.0074	.53	.0250	.0000	2.0
7380	June 1	June 2	V. slight.	Slight.	0.08	4.90	1.00	.0010	.0204	.0176	.0028	.54	.0050	.0001	1.9
7523	July 1	July 2	Slight.	Slight, green.	0.08	4.45	1.60	.0006	.0222	.0188	.0034	.44	.0030	.0003	1.8
7776	Aug. 10	Aug. 11	Slight.	Slight.	0.10	4.90	1.30	.0004	.0184	.0156	.0028	.48	.0070	.0000	2.6
7778	Aug. 10	Aug. 11	Distinct.	Slight.	0.10	4.80	0.95	.0004	.0210	.0158	.0052	.52	.0050	.0000	2.6
7896	Sept. 2	Sept. 3	Slight.	Slight.	0.03	5.25	1.60	.0000	.0214	.0180	.0034	.51	.0090	.0000	2.2
8009	Oct. 5	Oct. 6	Slight.	Cons., green.	0.08	5.20	1.30	.0036	.0268	.0178	.0090	.51	.0050	.0000	2.4
8202	Nov. 3	Nov. 4	Distinct.	Slight.	0.05	5.50	1.00	.0036	.0302	.0210	.0092	.56	.0050	.0000	2.2
8297	Dec. 3	Dec. 3	V. slight.	Slight.	0.08	5.15	1.40	.0040	.0234	.0194	.0040	.59	.0020	.0002	2.2
8378	Dec. 31	Jan. 1	Slight.	Slight.	0.05	5.30	1.75	.0042	.0178	.0150	.0028	.58	.0070	.0000	2.1
Av..	....	....	....	....	0.10	4.94	1.39	.0034	.0222	.0169	.0053	.51	.0152	.0001	2.1

Odor, generally vegetable or none, occasionally mouldy or disagreeable. The odors were disagreeable in October, November and the first part of December.——The samples were collected from the reservoir at the dam about one foot beneath the surface, with the exception of Nos. 7225 and 7778, which were collected from the reservoir near the inlet from Dike's Meadow Brook, and No. 7174, which was collected from a faucet in the town.

NOTE.—Where more than one sample has been taken in a month, the mean analysis for that month has been used in making the average given at the bottom of the table.

WINCHESTER.

Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1891.								
	Jan.	Feb.	Mar.	April.	April.	April.	April.	May.	June.
Day of examination,	7	5	7	7	7	21	21	16	3
Number of sample,	6873	6977	7092	7173	7174	7225	7226	7320	7380
PLANTS.									
Diatomaceæ,	**289**	**2**	**17**	**25,612**	**25,023**	**2,652**	**7,994**	**132**	**49**
Asterionella,	244	1	9	25,437	24,875	2,592	7,936	106	10
Cyclotella,	0	0	0	0	0	0	0	0	0
Diatoma,	0	0	0	50	70	0	6	pr.	0
Fragilaria,	0	0	0	0	0	0	0	0	0
Melosira,	0	0	2	0	0	0	0	0	9
Navicula,	0	0	1	pr.	0	0	0	0	0
Stephanodiscus,	44	0	0	124	78	24	32	26	30
Synedra,	1	1	5	0	0	20	0	0	0
Tabellaria,	0	0	0	1	0	16	20	pr.	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**58**	**30**
Anabæna,	0	0	0	0	0	0	0	58	0
Chroöcoccus,	0	0	0	0	0	0	0	0	2
Microcystis,	0	0	0	0	0	0	0	0	0
Nostoc,	0	0	0	0	0	0	0	0	28
Algæ,	**3**	**0**	**71**	**0**	**0**	**0**	**0**	**2**	**3**
Chlorococcus,	pr.	0	3	0	0	0	0	2	0
Pleurococcus,	0	0	68	0	0	0	0	0	0
Raphidium,	3	0	0	0	0	0	0	0	3
Fungi. Crenothrix,	**0**	**0**	**1**	pr.	**0**	**2**	**2**	**0**	pr.
ANIMALS.									
Rhizopoda,	pr.	**6**	**0**	**7**	pr.	**0**	**4**	**1**	pr.
Actinophrys,	pr.	0	0	0	0	0	2	1	0
Difflugia,	pr.	6	0	7	pr.	0	2	0	pr
Infusoria,	**3**	**6**	**3**	**11**	**14**	**58**	**46**	**600**	**0**
Dinobryon,	pr.	4	3	0	0	50	28	600	0
Dinobryon cases,	0	0	0	0	0	0	0	0	0
Glenodinium,	1	0	0	1	pr.	0	2	0	0
Monas,	pr.	0	pr.	0	0	pr.	0	0	0
Peridinium,	2	pr.	0	8	12	6	16	0	0
Trachelomonas,	pr.	2	0	2	2	2	0	0	0
Uroglena volvox,	0	0	0	0	0	0	0	0	0
Vermes,	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**1**	**1**
Anurea,	0	0	0	0	0	0	0	1	1
Rotifer,	0	0	0	0	0	4	0	0	0
Crustacea,	**0**	pr.	**0**	**0**	pr.	pr.	**0**	pr.	**0**
Bosmina,	0	0	0	0	0	pr.	0	pr.	0
Cyclops,	0	pr.	0	0	0	0	0	pr.	0
Daphnia,	0	0	0	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	**80**	**15**	**886**	**0**	**0**	**16**	**6**	**54**	**64**
TOTAL,	376	29	978	25,630	25,037	2,732	8,052	848	147

WINCHESTER.

Microscopical Examination of Water from the North Reservoir of the Winchester Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1891.							1892.
	July.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Day of examination,	2	12	12	4	6	5	4	2
Number of sample,	7523	7776	7778	7896	8009	8202	8297	8378
PLANTS.								
Diatomaceæ,	**0**	**0**	**9**	**1**	**49**	**98**	**180**	**51**
Asterionella,	0	0	0	0	25	47	156	31
Cyclotella,	0	0	0	1	0	18	16	7
Diatoma,	0	0	0	0	0	0	1	0
Fragilaria,	0	0	8	0	0	1	0	0
Melosira,	0	0	0	0	3	0	0	0
Navicula,	0	0	1	0	5	1	pr.	1
Stephanodiscus,	0	0	0	0	16	27	0	0
Synedra,	0	0	pr.	0	0	3	7	11
Tabellaria,	0	0	pr.	0	0	1	0	1
Cyanophyceæ,	**0**	**2**	**1**	**2**	**56**	**7**	**8**	**5**
Anabæna,	0	0	0	2	0	0	pr.	0
Chroöcoccus,	0	0	0	0	8	0	8	5
Microcystis,	0	2	1	0	48	7	0	0
Nostoc,	0	0	0	0	0	0	0	0
Algæ,	**0**	**0**	**4**	**0**	**26**	**6**	**5**	**1**
Chlorococcus,	0	0	4	0	16	6	5	0
Pleurococcus,	0	0	0	0	0	0	0	0
Raphidium,	0	0	0	0	10	0	0	1
Fungi. Crenothrix,	**9**	**3**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.								
Rhizopoda,	**0**	**0**	**0**	**pr.**	**2**	**0**	**0**	**0**
Actinophrys,	0	0	0	pr.	2	0	0	0
Difflugia,	0	0	0	0	0	0	0	0
Infusoria,	**0**	**2**	**1**	**51**	**1,799**	**7**	**13**	**4**
Dinobryon,	0	0	0	13	0	0	0	0
Dinobryon cases,	0	0	pr.	0	1,720	0	0	0
Glenodinium,	0	0	0	24	2	0	10	3
Monas,	0	0	0	0	0	pr.	0	pr.
Peridinium,	0	0	0	0	1	0	pr.	0
Trachelomonas,	0	2	1	14	172	7	13	1
Uroglena volvox,	0	0	0	0	4	0	0	0
Vermes,	**0**	**pr.**	**0**	**0**	**0**	**pr.**	**0**	**pr.**
Anurea,	0	0	0	0	0	pr.	0	pr.
Rotifer,	0	pr.	0	0	0	0	0	0
Crustacea,	**0**	**0**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**0**
Bosmina,	0	0	0	0	0	0	0	0
Cyclops,	0	0	pr.	pr.	0	pr.	pr.	0
Daphnia,	0	0	0	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	**0**	**46**	**50**	**234**	**476**	**126**	**66**	**20**
TOTAL,	9	53	65	288	2,408	244	274	81

WINCHESTER.

Chemical Examination of Water from the South Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
7777	Aug. 10	Aug. 11	Distinct.	Cons.	0.70	5.80	2.30	.0058	.0324	.0302	.0022	.48	.0000	.0000	2.3
7895	Sept. 2	Sept. 3	Slight.	Slight, rusty.	0.55	5.30	2.10	.0070	.0398	.0300	.0098	.35	.0120	.0000	2.2
8010	Oct. 5	Oct. 6	Decided, green.	Cons., rusty.	0.40	5.60	2.35	.0034	.0774	.0402	.0372	.36	.0030	.0000	2.5
8203	Nov. 3	Nov. 4	Slight.	Slight.	0.70	6.40	1.90	.0220	.0514	.0432	.0082	.40	.0120	.0025	2.4
8296	Dec. 3	Dec. 3	V. slight.	V. slight.	0.65	5.55	1.80	.0168	.0422	.0372	.0050	.40	.0200	.0005	1.9
Av.	....	... .	....	....	0.60	5.73	2.09	.0110	.0486	.0361	.0125	.40	.0094	.0006	2.3

Odor, vegetable, becoming stronger on heating.——The samples were collected from the reservoir near the gate-house a few inches beneath the surface. At the time these samples were collected the reservoir was filling for the first time, and the water level was from 13 to 16 feet below high-water mark; the water was consequently all contained in the lower division of the reservoir.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	4	6	5	4
Number of sample,	7777	7895	8010	8203	8296
PLANTS.					
Diatomaceæ,	**122**	**14**	**213**	**6**	**2**
Asterionella,	122	7	192	pr.	0
Cyclotella,	0	4	0	0	0
Navicula,	0	0	2	0	0
Synedra,	0	3	19	6	2
Cyanophyceæ,	**16**	**564**	**2,138**	**pr.**	**0**
Anabæna,	4	564	2,088	pr.	0
Anabæna spores,	12	0	0	0	0
Chroöcoccus,	0	0	50	0	0
Algæ,	**9**	**2**	**4**	**18**	**1**
Chlorococcus,	9	0	4	0	0
Dictyosphærium,	0	0	0	18	0
Raphidium,	0	2	0	0	1
Fungi. Crenothrix,	**25**	**1**	**2**	**7**	**3**

WINCHESTER.

Microscopical Examination of Water from the South Reservoir of the Winchester Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1891.				
	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.					
Rhizopoda,	**0**	**0**	**3**	**1**	**2**
Actinophrys,	0	0	0	1	2
Difflugia,	0	0	3	0	0
Infusoria,	**4**	**5**	**3**	**8**	**1**
Cryptomonas,	0	0	1	4	0
Spongomonas,	0	0	0	1	0
Trachelomonas,	4	5	2	3	1
Vermes,	**pr.**	**0**	**3**	**3**	**0**
Anurea,	pr.	0	3	pr.	0
Triarthra,	0	0	0	3	0
Crustacea,	**0**	**pr.**	**0**	**pr.**	**pr.**
Cyclops,	0	pr.	0	pr.	pr.
Daphnia,	0	pr.	0	0	0
Miscellaneous. Zoöglœa,	**4**	**736**	**496**	**15**	**20**
TOTAL,	180	1,322	2,862	58	29

Table showing Heights of Water in the North Reservoir of the Winchester Water Works at times when Samples of Water were collected for Analysis.

NOTE. — High-water mark is 25.0 feet.

Date.	Height of Water.	Date.	Height of Water.
1891.	Feet.	**1891** — Con.	Feet.
Jan. 5,	25.0	July 1,	22.0
Feb. 3,	25.0	Aug. 10,	20.5
Mar. 3,	25.0	Sept. 2,	19.3
Apr. 6,	25.0	Oct. 5,	19.0
Apr. 20,	24.8	Nov. 3,	18.5
May 14,	-	Dec. 3,	18.0
June 1,	24.0		

WATER SUPPLY OF WINTHROP.

(See *Revere*.)

WATER SUPPLY OF WOBURN.

Chemical Examination of Water from the Filter-gallery of the Woburn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
6878	Jan. 6	Jan. 7	None.	None.	0.0	12.20	.0014	.0016	1.76	.0620	.0001	5.0
6984	Feb. 4	Feb. 5	None.	None.	0.0	10.25	.0008	.0020	2.00	.1000	.0000	5.0
7099	Mar. 9	Mar. 11	None.	None.	0.0	9.85	.0006	.0026	1.82	.0750	.0001	4.7
7191	April 7	Apr. 8	None.	None.	0.0	9.80	.0000	.0014	1.65	.0750	.0000	4.6
7289	May 6	May 7	None.	None.	0.0	10.40	.0000	.0014	1.61	.0850	.0000	4.7
7387	June 2	June 4	None.	None.	0.0	10.30	.0012	.0026	1.72	.0700	.0000	4.4
7542	July 7	July 8	None.	None.	0.0	11.05	.0014	.0012	1.89	.1100	.0001	4.9
7787	Aug. 11	Aug. 12	None.	None.	0.0	10.95	.0014	.0018	1.87	.0500	.0001	5.6
7904	Sept. 4	Sept. 5	None.	None.	0.0	11.15	.0000	.0010	1.92	.0500	.0000	4.7
8060	Oct. 13	Oct. 14	None.	None.	0.0	12.05	.0018	.0008	1.79	.0400	.0000	4.6
8205	Nov. 3	Nov. 4	None.	V. slight.	0.0	11.55	.0010	.0018	1.84	.0350	.0000	4.7
8308	Dec. 7	Dec. 8	None.	None.	0.0	10.65	.0000	.0016	1.60	.0500	.0000	5.6
Av.	....	....	....	....	0.0	10.85	.0008	.0015	1.79	.0668	.0000	4.9

Odor, none.——The samples were collected from a faucet in the pumping station while pumping, with the exception of the last two, which were collected directly from the filter-gallery.

Microscopical Examination of Water from the Filter-gallery of the Woburn Water Works.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	5	11	10	12	4	8	13	5	14	5	9
Number of sample,	6878	6984	7099	7191	7289	7387	7542	7787	7904	8060	8205	8308
PLANTS.												
Diatomaceæ,	**9**	**0**	**3**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**
Asterionella,	7	0	3	3	0	0	0	0	0	0	0	0
Synedra,	2	0	pr.	1	0	0	0	0	0	0	3	2
Miscellaneous. Zoöglœa,	**0**	**0**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**pr.**	**2**	**0**
TOTAL,	9	0	6	4	1	0	0	0	0	pr.	5	2

WOBURN.

Chemical Examination of Water from the Distributing Reservoir of the Woburn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.											
7403	June 6	June 8	None.	None.	0.0	10.80	.0004	.0014	1.75	.0600	.0001	4.3
7541	July 7	July 8	V. slight.	None.	0.0	11.15	.0000	.0018	1.89	.1100	.0001	4.9
7788	Aug. 11	Aug. 12	None.	None.	0.0	12.15	.0000	.0022	1.90	.0600	.0002	5.7
7905	Sept. 4	Sept. 5	None.	V. slight.	0.0	11.40	.0000	.0014	1.88	.0500	.0000	4.7
8059	Oct. 13	Oct. 14	None.	V. slight.	0.0	11.30	.0000	.0040	1.78	.0400	.0001	4.6
8206	Nov. 3	Nov. 4	None.	None.	0.0	11.10	.0006	.0012	2.00	.0400	.0000	4.7
8307	Dec. 7	Dec. 8	None.	None.	0.0	11.25	.0014	.0020	2.05	.0520	.0005	5.3
Av..	....	....	....	....	0.0	11.31	.0003	.0020	1.89	.0589	.0001	4.9

Odor, generally none; in August distinctly vegetable and unpleasant. —— The samples were colected either from a faucet at the pipe shop, or from a faucet in a dwelling-house near the pipe shop. These are the first two taps on the pipe line leading from the reservoir to the city.

Microscopical Examination of Water from the Distributing Reservoir of the Woburn Water Works.

[Number of organisms per cubic centimeter.]

	1891. June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	7	8	13	5	14	4	9
Number of sample, ...	7403	7541	7788	7905	8059	8206	8307
PLANTS.							
Diatomaceæ, ...	0	0	0	0	0	pr.	113
Asterionella, ...	0	0	0	0	0	0	23
Diatoma, ...	0	0	0	0	0	0	58
Melosira, ...	0	0	0	0	0	0	23
Synedra, ...	0	0	0	0	0	pr.	9
Algæ, ...	0	0	1	0	57	0	pr.
Chlorococcus, ...	0	0	0	0	54	0	pr.
Spirogyra, ...	0	0	1	0	3	0	0
Fungi. Crenothrix, ...	50	0	0	48	1	0	4
ANIMALS.							
Crustacea. Cyclops, ...	0	0	0	0	0	0	pr.
Miscellaneous. Zoöglœa, ...	0	0	0	0	12	4	26
Total, ...	50	0	1	48	70	4	143

WOBURN.

Chemical Examination of Water from Horn Pond in Woburn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid Total.	Ammonia. Albuminoid Dissolved.	Ammonia. Albuminoid Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6877	Jan. 6	Jan. 7	V. slight.	Slight.	0.40	9.10	2.15	.0174	.0212	.0186	.0026	1.59	.1000	.0015	3.2
6983	Feb. 4	Feb. 5	Decided.	Slight.	0.30	5.55	1.60	.0198	.0190	.0168	.0022	0.76	.0650	.0005	2.2
7098	Mar. 9	Mar. 11	V. slight.	V. slight.	0.30	6.00	1.85	.0194	.0214	.0150	.0064	1.01	.0950	.0003	2.2
7190	Apr. 7	Apr. 8	Decided.	Slight.	0.30	8.10	1.30	.0290	.0194	.0150	.0044	1.48	.0950	.0015	2.6
7288	May 6	May 7	Distinct.	Cons., green.	0.20	7.10	1.55	.0008	.0322	.0156	.0166	1.27	.0900	.0010	3.0
7386	June 2	June 4	Slight.	Cons.	0.20	7.50	1.75	.0064	.0336	.0214	.0122	1.35	.0600	.0010	2.6
7540	July 7	July 8	Decided.	Cons., green.	0.20	8.65	2.15	.0006	.0420	.0236	.0184	1.65	.0150	.0010	2.6
7786	Aug. 11	Aug. 12	Decided.	Cons., green.	0.15	9.80	2.05	.0000	.0396	.0240	.0156	2.11	.0050	.0000	3.0
7903	Sept. 4	Sept. 5	Distinct, green.	Cons.	0.20	10.85	2.30	.0000	.0980	.0308	.0672	2.36	.0070	.0005	3.1
8058	Oct. 13	Oct. 14	Distinct, green.	Cons., green.	0.15	11.75	3.75	.0154	.0990	.0322	.0668	2.31	.0100	.0005	3.1
8204	Nov. 3	Nov. 4	Distinct.	Slight.	0.10	11.25	2.15	.0302	.0696	.0400	.0296	2.58	.0200	.0025	3.1
8306	Dec. 7	Dec. 8	Distinct.	Slight.	0.15	11.10	2.10	.0162	.0482	.0312	.0170	2.62	.0400	.0005	3.5
Av.	....	....	....	....	0.22	8.90	2.06	.0129	.0453	.0237	.0216	1.76	.0502	.0009	2.9

Odor, generally distinctly vegetable and grassy, rarely none, becoming stronger on heating, and sometimes mouldy or unpleasant.——The samples were collected from the pond near the pumping station, at a depth of about four feet beneath the surface, with the exception of Nos. 8204 and 8306, which were collected from near the surface.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	5	11	10	13	4	8	13	5	14	5	9
Number of sample,	6877	6983	7098	7190	7288	7386	7540	7786	7903	8058	8204	8306
PLANTS.												
Diatomaceæ,	**651**	**18**	**9**	**258**	**2,596**	**331**	**96**	**7**	**66**	**11**	**18**	**1,041**
Asterionella,	480	15	9	76	294	32	0	0	0	0	0	176
Cyclotella,	0	0	0	58	0	0	0	0	0	0	1	4
Diatoma,	0	0	0	0	0	1	0	0	0	0	0	124
Fragilaria,	0	0	0	0	0	0	0	7	66	0	0	5
Melosira,	154	2	0	20	8	0	0	0	0	10	17	540
Meridion,	0	0	0	28	0	0	0	0	0	0	0	0
Nitzschia,	0	1	0	0	1,748	298	0	0	0	0	0	0
Stephanodiscus,	1	0	0	0	pr.	0	96	0	0	0	0	0
Synedra,	16	0	pr.	76	546	0	0	0	0	1	0	192

WOBURN.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	0	0	0	0	0	16	108	89	3,640	370	939	10
Anabæna,	0	0	0	0	0	pr.	0	0	0	162	902	0
Aphanocapsa,	0	0	0	0	0	0	4	pr.	8	0	0	0
Chroöcoccus,	0	0	0	0	0	2	30	6	0	4	0	10
Clathrocystis,	0	0	0	0	0	13	60	35	72	18	1	0
Cœlosphærium,	0	0	0	0	0	1	14	9	4	0	0	0
Microcystis,	0	0	0	0	0	0	0	39	52	2	0	0
Nostoc,	0	0	0	0	0	0	0	0	3,504	184	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	0	0	36	0
Algæ,	19	0	0	25	37	44	8,966	37	8	12	21	115
Chlorococcus,	0	0	0	0	7	11	8,704	28	0	0	2	7
Cosmarium,	pr.	0	0	1	8	22	128	6	0	4	0	0
Pediastrum,	0	0	0	0	pr.	6	2	0	0	1	0	0
Raphidium,	2	0	0	0	0	1	0	0	0	0	0	4
Scenedesmus,	17	0	0	2	22	4	122	3	8	7	19	104
Zoöspores,	0	0	0	22	0	0	0	0	0	0	0	0
Fungi. Beggiatoa,	0	0	0	0	0	0	0	0	8	1	0	0
ANIMALS.												
Rhizopoda. Actinophrys,	2	0	0	0	0	0	0	0	0	0	0	0
Infusoria,	3	0	0	pr.	1	pr.	1	2	0	1	9	219
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	218
Monas,	0	0	0	0	pr.	0	0	2	0	1	pr.	1
Peridinium cases,	0	0	0	0	0	0	0	0	0	0	9	0
Trachelomonas,	3	0	0	pr.	1	pr.	1	0	0	0	0	0
Vermes,	0	0	0	0	pr.	3	1	0	10	0	1	0
Anurea,	0	0	0	0	pr.	0	1	0	4	0	1	0
Monocerca,	0	0	0	0	0	0	0	0	2	0	0	0
Polyarthra,	0	0	0	0	0	3	0	0	0	0	0	0
Trachelocerca,	0	0	0	0	0	0	0	0	4	0	0	0
Crustacea,	0	0	pr.	0	pr.	pr.	pr.	0	0	0	0	pr.
Bosmina,	0	0	0	0	pr.	pr.	0	0	0	0	0	0
Cyclops,	0	0	pr.	0	0	pr.	pr.	0	0	0	0	pr.
Miscellaneous. Zoöglœa,	0	62	0	494	334	6	0	0	0	408	16	66
TOTAL,	675	80	9	777	2,968	400	9,172	135	3,732	803	1,004	1,451

Water Supply of Worcester.

Leicester Supply.— *Chemical Examination of Water from the Inlet to the Lynde Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7007	Feb. 12	Feb. 13	None.	Slight.	0.30	2.85	1.20	.0004	.0082	.0054	.0028	.08	.0090	.0001	0.8
7209	Apr. 13	Apr. 14	V. slight.	Cons.	0.20	2.55	0.85	.0004	.0084	.0068	.0016	.08	.0070	.0000	0.8
7301	May 11	May 12	V. slight.	V. slight.	0.45	2.90	1.30	.0000	.0160	.0120	.0040	.09	.0060	.0000	0.6
7408	June 8	June 10	None.	V. slight.	0.50	3.50	1.45	.0002	.0140	.0106	.0034	.06	.0050	.0001	0.9
7551	July 13	July 14	V. slight.	Cons.	0.20	2.70	1.10	.0000	.0134	.0102	.0032	.14	.0020	.0000	0.6
7821	Aug. 16	Aug. 18	None.	V. slight.	0.20	4.50	1.45	.0004	.0130	.0118	.0012	.12	.0000	.0000	1.3
7934	Sept. 15	Sept. 16	V. slight.	V. slight.	0.50	4.40	1.75	.0008	.0134	.0114	.0020	.14	.0000	.0001	0.5
8053	Oct. 13	Oct. 14	V. slight.	None.	0.10	4.15	1.25	.0000	.0114	.0094	.0020	.27	.0050	.0001	1.6
8250	Nov. 10	Nov. 11	V. slight.	V. slight.	0.45	3.90	1.10	.0120	.0144	.0122	.0022	.19	.0200	.0002	0.9
8349	Dec. 17	Dec. 19	V. slight.	Slight.	0.65	5.50	2.00	.0000	.0114	.0094	.0020	.22	.0150	.0001	1.7
Av.	....	....	....	....	0.35	3.69	1.34	.0014	.0124	.0099	.0025	.14	.0069	.0001	1.0

Odor, generally faintly vegetable, sometimes none.—The samples were collected from Lynde Brook a short distance above the point where it enters the Leicester storage reservoir.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1891. Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	14	16	13	9	14	18	16	14	12	19
Number of sample, ...	7007	7209	7301	7408	7551	7821	7934	8053	8250	8349
PLANTS.										
Diatomaceæ, ...	7	21	17	9	78	19	9	pr.	2	8
Asterionella, ...	0	0	0	1	52	0	0	0	0	0
Cyclotella, ...	0	0	0	0	23	0	0	0	0	0
Diatoma, ...	0	8	0	2	0	0	0	0	0	0
Melosira, ...	0	4	0	0	pr.	0	5	0	0	0
Meridion, ...	0	4	0	0	0	0	1	pr.	1	0
Navicula, ...	0	pr.	1	2	2	12	1	pr.	0	2
Synedra, ...	7	3	16	4	1	0	2	0	1	3
Tabellaria, ...	0	2	0	0	0	7	0	0	0	3
Cyanophyceæ. Chroöcoccus, .	0	0	0	0	28	0	0	0	0	0

WORCESTER.

LEICESTER SUPPLY. — *Microscopical Examination of Water from the Inlet to the Lynde Brook Storage Reservoir* — Concluded.

[Number of organisms per cubic centimeter.]

	1891.									
	Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.										
Algæ,	**0**	**0**	**0**	**0**	**29**	**11**	**0**	**0**	**0**	**0**
Chlorococcus,	0	0	0	0	15	0	0	0	0	0
Desmidium,	0	0	0	0	0	6	0	0	0	0
Raphidium,	0	0	0	0	5	0	0	0	0	0
Staurastrum,	0	0	0	0	4	5	0	0	0	0
Staurogenia,	0	0	0	0	5	0	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**1**	**0**	**0**	**0**	**7**	**0**	**7**	**1**
ANIMALS.										
Infusoria. Dinobryon,	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**92**	**110**	**57**	**2**	**108**	**0**	**162**	**0**	**132**	**19**
TOTAL,	99	131	75	11	251	30	178	pr.	141	28

LEICESTER SUPPLY. — *Chemical Examination of Water from the Lynde Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6905	Jan. 15	Jan. 16	Slight.	Slight.	0.03	2.80	0.75	.0040	.0136	.0116	.0020	.11	.0150	.0000	0.9
7008	Feb. 12	Feb. 13	V. slight.	V. slight.	0.30	2.25	1.10	.0018	.0098	.0078	.0020	.13	.0090	.0001	0.6
7106	Mar. 10	Mar. 11	V. slight.	None.	0.10	2.05	0.70	.0022	.0098	.0080	.0018	.07	.0150	.0001	0.6
7210	Apr. 13	Apr. 14	V. slight.	V. slight.	0.20	2.80	0.75	0026	.0114	.0074	.0040	.08	.0100	.0000	0.8
7300	May 11	May 12	Slight.	Slight.	0.25	2.80	0.95	.0020	.0116	.0106	.0010	.11	.0090	.0000	0.8
7354	May 25	May 26	V. slight.	Slight.	0.10	3.05	1.20	.0028	.0106	.0098	.0008	.14	.0070	.0001	0.6
7409	June 8	June 10	Slight.	Slight, green.	0.10	2.65	0.65	.0000	.0168	.0110	.0058	.09	.0090	.0002	0.6
7552	July 13	July 14	V. slight.	V. slight.	0.15	2.45	1.05	.0004	.0110	.0094	.0016	.13	.0020	.0000	0.5
7822	Aug. 16	Aug. 18	V. slight.	V. slight.	0.10	3.00	0.95	.0000	.0110	.0094	.0016	.12	.0000	.0000	0.8
7935	Sept. 15	Sept. 16	V. slight.	Slight.	0.15	2.85	1.25	.0000	.0140	.0122	.0018	.15	.0000	.0001	0.3
8054	Oct. 13	Oct. 14	Slight.	Slight.	0.80	2.90	1.20	.0146	.0150	.0102	.0048	.13	.0050	.0001	0.8
8251	Nov. 10	Nov. 11	V. slight.	Slight.	0.45	3.25	1.65	.0204	.0162	.0140	.0022	.15	.0050	.0002	0.6
8326	Dec. 14	Dec. 15	V. slight.	V. slight.	0.45	3.95	1.25	.0076	.0134	.0106	.0028	.15	.0100	.0002	0.6
Av..	....	....	....	....	0.24	2.83	1.03	.0045	.0126	.0101	.0025	.12	.0074	.0001	0.7

Odor, generally faintly vegetable or none, becoming stronger on heating and frequently mouldy or disagreeable. —— The samples were collected from the reservoir in front of the gate-house at a depth of one foot beneath the surface, with the exception of No. 6905, which was collected from the foot of the waste-way.

WORCESTER.

LEICESTER SUPPLY. — *Microscopical Examination of Water from the Lynde Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

	1891.												
	Jan.	Feb.	Mar.	Apr.	May.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	14	12	16	13	26	9	14	18	16	14	12	15
Number of sample,	6905	7008	7106	7210	7300	7354	7409	7552	7822	7935	8054	8251	8326
PLANTS.													
Diatomaceæ,	**0**	**24**	**0**	**pr.**	**7**	**19**	**69**	**104**	**0**	**2**	**0**	**4**	**1**
Asterionella,	0	0	0	0	0	1	0	76	0	0	0	0	0
Cyclotella,	0	0	0	0	0	0	0	28	0	1	0	pr.	1
Melosira,	0	0	0	0	2	0	0	0	0	0	0	3	0
Navicula,	0	0	0	0	0	0	0	0	0	1	0	1	pr.
Stephanodiscus,	0	0	0	pr.	4	18	69	0	0	0	0	0	0
Synedra,	0	24	0	0	1	0	0	pr.	0	pr.	0	0	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**pr.**	**29**	**63**	**24**	**0**	**0**	**0**	**0**
Chroöcoccus,	0	0	0	0	0	0	0	62	0	0	0	0	0
Nostoc,	0	0	0	0	0	pr.	29	1	24	0	0	0	0
Algæ,	**1**	**1**	**10**	**4**	**pr.**	**30**	**26**	**26**	**260**	**1,590**	**797**	**4**	**0**
Botryococcus,	0	0	0	0	0	3	16	0	0	0	0	0	0
Chlorococcus,	0	1	0	0	0	25	6	17	256	0	796	4	0
Nephrocytium,	0	0	0	0	0	0	0	0	0	9	0	0	0
Pleurococcus,	0	0	0	0	0	0	0	0	0	1,574	0	0	0
Protococcus,	1	0	1	4	0	0	0	0	0	0	0	0	0
Raphidium,	0	0	0	0	0	0	0	6	4	6	1	0	0
Staurogenia,	0	0	0	0	0	2	4	3	0	pr.	0	0	0
Zoöspores,	0	0	9	0	pr.	0	0	0	0	1	pr.	0	0
Fungi. Crenothrix,	**3**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**pr.**	**2**	**0**	**0**
ANIMALS.													
Infusoria,	**0**	**5**	**8**	**2**	**5**	**8**	**0**	**4**	**0**	**2**	**pr.**	**20**	**1**
Cryptomonas,	0	0	0	0	0	0	0	0	0	pr.	0	5	0
Dinobryon,	0	5	8	0	5	8	0	4	0	0	0	0	0
Monas,	0	0	0	1	0	0	0	0	0	1	0	6	0
Peridinium,	0	pr.	0	1	0	0	0	0	0	1	pr.	7	1
Trachelomonas,	0	0	0	0	0	pr.	0	0	0	0	0	2	0
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**948**	**3**	**0**	**380**	**132**	**24**	**5**	**10**	**27**	**176**	**460**	**208**	**0**
TOTAL,	952	33	18	386	144	81	129	207	311	1,770	1,259	236	2

WORCESTER.

LEICESTER SUPPLY. — *Chemical Examination of Water from a Faucet in Worcester, supplied from the Leicester Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7353	May 25	May 26	Slight.	Cons., rusty.	0.10	3.40	1.35	.0000	.0140	.0110	.0030	.13	.0090	.0000	0.8

Odor, strongly vegetable and disagreeable.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 1; *Epithemia*, pr.; *Melosira*, 2; *Navicula*, 8; *Tabellaria*, pr. Cyanophyceæ, *Chroöcoccus*, 5. Algæ, *Gonium*, 1; *Nephrocytium*, pr.; *Zoöspores*, pr. Vermes, *Anurea*, pr. Miscellaneous, *Zoöglœa*, 368. *Sponge spicules*, pr. Total, 385.

HOLDEN SUPPLY. — *Chemical Examination of Water from Tatnuck Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6888	Jan. 12	Jan. 13	V. slight.	V. slight.	0.40	2.55	0.75	.0134	.0150	.0132	.0018	.08	.0100	.0000	0.9
7006	Feb. 12	Feb. 12	None.	V. slight.	0.20	2.30	0.85	.0012	.0070	.0054	.0016	.07	.0070	.0001	0.6
7107	Mar. 10	Mar. 11	V. slight.	Slight.	0.08	2.05	0.85	.0018	.0094	.0078	.0016	.10	.0180	.0001	0.5
7211	Apr. 13	Apr. 14	V. slight.	V. slight.	0.05	1.65	0.50	.0000	.0072	.0056	.0016	.07	.0100	.0000	0.5
7299	May 11	May 12	Slight.	Slight, white.	0.15	1.65	0.60	.0002	.0108	.0090	.0018	.11	.0070	.0000	0.2
7410	June 8	June 10	Distinct.	Slight.	0.10	2.40	0.85	.0002	.0108	.0084	.0024	.08	.0050	.0000	0.3
7553	July 13	July 14	Slight.	Slight, white.	0.12	2.05	1.10	.0000	.0142	.0116	.0026	.09	.0020	.0001	0.2
7823	Aug. 16	Aug. 18	Distinct.	Cons.	0.10	2.15	1.00	.0000	.0164	.0096	.0068	.10	.0000	.0000	0.8
7936	Sept. 15	Sept. 16	Slight.	Cons.	0.15	2.65	1.40	.0002	.0196	.0126	.0070	.13	.0050	.0001	0.3
8052	Oct. 13	Oct. 14	Slight.	Cons.	0.10	2.30	1.20	.0000	.0222	.0144	.0078	.12	.0050	.0001	0.3
8249	Nov. 10	Nov. 11	Distinct.	Cons., green.	0.25	2.70	1.15	.0100	.0248	.0154	.0094	.15	.0120	.0002	0.2
8327	Dec. 14	Dec. 15	Slight.	Slight.	0.35	3.10	1.00	.0014	.0148	.0096	.0052	.18	.0120	.0003	0.6
Av.	....	....	....	....	0.17	2.30	0.94	.0024	.0143	.0102	.0041	.11	.0077	.0001	0.4

Odor, generally vegetable, occasionally somewhat unpleasant or disagreeable, sometimes none. —— The samples were collected from the reservoir in front of the gate house, one foot beneath the surface, or at the foot of the rollway where water overflows from the reservoir, with the exception of Nos. 8052 and 8327, which were collected from a 30-inch discharge pipe at the foot of the dam.

WORCESTER.

HOLDEN SUPPLY.—*Microscopical Examination of Water from Tatnuck Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	14	14	12	16	13	9	14	18	17	14	12	15
Number of sample,	6888	7006	7107	7211	7299	7410	7553	7823	7936	8052	8249	8327
PLANTS.												
Diatomaceæ,	143	24	28	196	567	160	826	177	1,934	348	2,222	233
Asterionella,	2	0	0	6	12	7	474	14	180	18	186	116
Diatoma,	0	0	4	8	pr.	2	0	0	0	0	0	0
Melosira,	7	4	5	65	336	19	176	120	1,036	286	1,246	72
Navicula,	0	0	2	2	1	1	0	pr.	2	4	2	pr.
Nitzschia,	0	0	16	0	0	0	0	0	0	0	0	0
Synedra,	38	20	pr.	11	60	55	15	0	108	0	0	11
Tabellaria,	96	pr.	1	104	158	76	161	43	608	40	788	34
Cyanophyceæ. Chroöcoccus,	0	0	0	0	0	0	0	59	0	20	3	0
Algæ,	2	0	0	1	19	1	1	12	40	6	60	5
Conferva,	0	0	0	1	0	0	0	0	2	0	36	4
Raphidium,	0	0	0	0	0	0	1	0	0	2	19	0
Scenedesmus,	0	0	0	pr.	1	1	0	11	10	1	5	1
Staurastrum,	pr.	0	0	0	1	pr.	pr.	1	28	0	pr.	pr.
Zoöspores,	2	0	0	0	17	0	0	pr.	0	3	0	0
ANIMALS.												
Rhizopoda,	0	0	0	1	pr.	0	0	1	3	1	2	0
Actinophrys,	0	0	0	0	0	0	0	1	1	0	1	0
Arcella,	0	0	0	1	pr.	0	0	0	0	0	0	0
Difflugia,	0	0	0	0	0	0	0	0	2	1	1	0
Infusoria,	36	0	pr.	2	2	17	8	343	99	9	2	0
Dinobryon,	36	0	0	2	0	0	1	0	0	0	0	0
Dinobryon cases,	0	0	0	0	0	0	0	234	0	0	0	0
Glenodinium,	0	0	0	0	0	10	0	pr.	96	0	1	0
Monas,	0	0	0	0	0	0	0	2	0	0	pr.	0
Peridinium,	pr.	0	pr.	pr.	2	pr.	6	105	0	9	1	0
Trachelomonas,	0	0	0	pr.	0	7	1	2	3	0	pr.	0
Vermes,	0	0	pr.	0	0	pr.	pr.	pr.	3	pr.	5	1
Anuræa,	0	0	pr	0	0	pr.	pr.	pr.	0	pr.	pr.	0
Monocerca,	0	0	0	0	0	0	0	0	2	0	0	1
Polyarthra,	0	0	0	0	0	0	pr.	0	1	pr.	5	0
Crustacea,	pr.	0	0	0	0	0	0	pr.	pr.	0	pr.	pr.
Bosmina,	0	0	0	0	0	0	0	0	0	0	pr.	pr.
Cyclops,	pr.	0	0	0	0	0	0	pr.	pr.	0	pr.	0
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	94	0	272	108	126	3	81	184	620	34	222	54
TOTAL,	275	24	300	308	714	181	916	786	2,699	418	2,516	293

WORCESTER.

Record of Heights of Water in Holden and Leicester Storage Reservoirs at Times when Samples of Water were collected for Analysis.

NOTE.—Holden Reservoir, height of rollway, 20.10 feet; Leicester Reservoir, height of rollway, 37.40 feet.

DATE.	Height of Water.		DATE.	Height of Water.	
	Holden.	Leicester.		Holden.	Leicester.
1891.			1891.		
Jan. 12,	20.82	38.35	July 13,	16.32	33.98
Feb. 12,	20.48	37.63	Aug. 16,	13.20	31.62
Mar. 10,	20.88	38.17	Sept. 15,	11.95	30.50
Apr. 13,	20.35	37.95	Oct. 13,	8.84	27.97
May 11,	19.92	36.95	Nov. 10,	7.20	25.77
June 8,	18.80	36.16	Dec. 14,	9.08	25.20

EXAMINATIONS OF WATER SUPPLIES AND RIVERS.

RIVERS.

EXAMINATION OF RIVERS.

The regular monthly examination of the waters of three rivers has been continued during the past year. The Blackstone has been examined at four points, the Merrimack at two and the Taunton at one.

Advantage was taken of a drier season than any other since the Board began its regular examinations of water supplies and rivers in 1887, to make special examinations of five rivers, viz., the Blackstone, Quaboag (a branch of the Chicopee), Merrimack, Nashua and Neponset.

Occasional examinations have been made of water from some of the other rivers of the State, and the results are printed in connection with the water supplies of the towns where the samples were collected, and can be found on previous pages of this volume as follows: —

Charles River at Newton, ...	page 186
Salisbury Plain River at Brockton, ...	" 105
Town River at Bridgewater, ...	" 99

Nearly all of the examinations show an increasing pollution of the streams as compared with previous years. This is caused not only by the fact that the summer and autumn of 1891 were drier than for several years before, but also by an unusually rapid increase in population and manufactures during these years, little being done by the towns and manufacturers to keep the larger streams from becoming polluted.

Blackstone River.

A detailed description of the Blackstone River and of the various ways in which it is polluted was given in the special report of the Board on the Examination of Water Supplies, 1890, page 383. As there stated, the Blackstone is the most polluted river in Massachusetts, due for the most part to the sewage and manufacturing refuse

of the city of Worcester, situated at the head of the river. Until June 25, 1890, all of the Worcester sewage went directly into this stream through the Mill Brook channel; but since that date a portion of the sewage has been treated at the chemical precipitation works, located near the river, about one mile south of Quinsigamond Village.

In order to show clearly the points at which the Worcester sewage and the effluent from the precipitation works enter the river, and the relation of these points to the places where samples have been collected, a diagram is given upon the opposite page. This is not drawn to scale, but is merely a sketch showing the relation of the sewage outlets and sewerage works to the river, and the average quantity of water or sewage flowing in the different channels during the week ending July 29, 1891, when a special examination of the river was made.

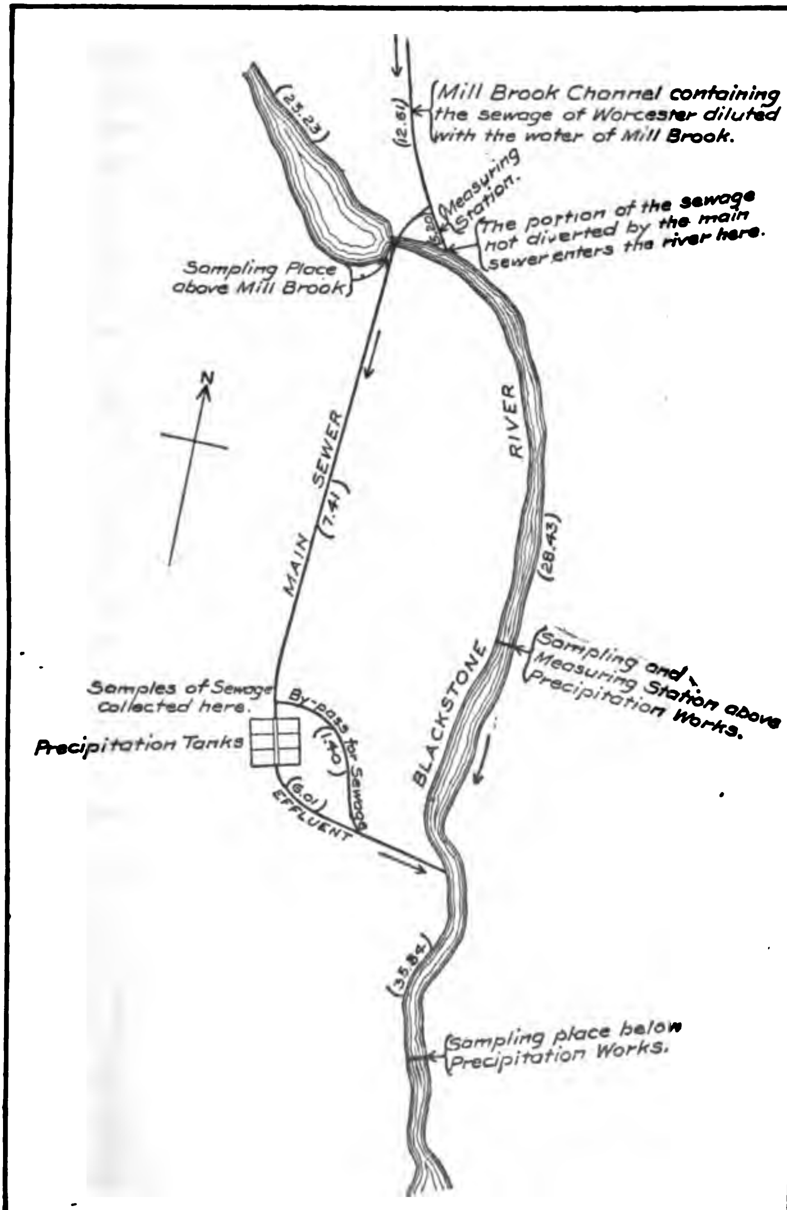
Nearly all of the sewage of the city flows into the channel of Mill Brook, which has practically been converted into a sewer. As, however, this brook receives the natural drainage from a water-shed of about 12.5 square miles, the sewage is diluted and its volume very greatly increased by mingling with the brook water. At the present time the main sewer leading to the precipitation works extends only up to the mouth of the Mill Brook channel, so that the sewage treated does not come directly from the sewers, but is the diluted sewage flowing in this channel. On account of the large volume, it is possible with the present works to treat only a portion of this sewage, even in the summer time when the flow is least. The precipitation works were designed to treat 4,500,000 gallons per day, but, during the drier portions of 1891, they were used to treat as much as 6,000,000 gallons, though this amount could not be treated quite as effectively as a smaller quantity. The greater part of the untreated sewage now, as in the past, flows into the river at the mouth of the Mill Brook channel; but it is the custom to divert to the precipitation works somewhat more sewage than can be treated, and to turn the surplus into the river through a by-pass.

At the precipitation works the sewage is treated with chemicals and then caused to flow slowly through settling tanks. The clarified effluent is discharged through a ditch into the river. The precipitated sludge is disposed of by pumping it upon land near the river, and some of it after drying has been burned.

BLACKSTONE RIVER.

Diagram showing the Relation of the Worcester Sewerage Works to the Blackstone River (not drawn to scale).

Note. — Figures in parentheses express the average flow in millions of gallons per twenty-four hours through the different channels during the week, beginning at 8 A.M., July 22, 1891.



BLACKSTONE RIVER.

As the amount of sewage discharged without treatment is much greater than the amount treated, the river is still very foul and during the past year has been the cause of much complaint from those living near it below Worcester.

The regular monthly examinations of the river at several points have now been continued since June, 1887, and it is feasible to prepare tables by which the average results obtained in the different years can be compared. Two tables are presented, one showing the average results for each calendar year and the other giving the average results for the six months of each year from June to November, inclusive, the latter representing the drier half of the year. The Worcester precipitation works were first operated in July, 1890, and since that date samples have been taken from the river above and below the works, while before only one sample was collected. As no sewage then entered the river at the precipitation works it may be fairly assumed that for all previous months the water had the same character above and below the works.

Following these tables of averages will be found, first, the detailed tables of analyses of the regular monthly samples; second, a description of the special examination of the river and sewerage works, made in July, 1891, together with the general results of this examination; and, finally, the tables giving in detail the measurements of the flow of the river and all of the analyses made in connection with this examination.

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR THE YEARS 1888 TO 1891, INCLUSIVE.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

YEAR.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
1888, ...	0.64	-	-	.2112	.1040	-	-	1.21	.0370	.0029	-
1889, ...	0.76	-	-	.2841	.1198	.0629	.0569	1.06	.0235	.0024	-
1890, ...	0.82	-	-	.1800	.1024	.0549	.0475	1.03	.0367	.0014	-
1891, ...	0.80	13.54	4.00	.3340	.1563	.0840	.0723	1.73	.0333	.0032	4.6

BLACKSTONE RIVER.

Blackstone River below Sewage Precipitation Works.

[Parts per 100,000.]

YEAR.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
1888,	0.64	-	-	.2112	.1040	-	-	1.21	.0370	.0029	-
1889,	0.76	-	-	.2841	.1198	.0629	.0569	1.06	.0235	.0024	-
1890,	0.74	-	-	.2253	.1177	.0581	.0596	1.26	.0381	.0016	-
1891,	0.80	15.62	4.52	.4080	.1303	.0695	.0608	1.91	.0358	.0031	4.6

Blackstone River at Uxbridge.

YEAR.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
1888,	0.45	-	-	.0979	.0284	-	-	0.61	.0322	.0008	-
1889,	0.28	-	-	.0992	.0300	.0191	.0109	0.60	.0253	.0009	-
1890,	0.25	-	-	.1168	.0214	.0152	.0062	0.66	.0272	.0006	-
1891,	0.27	8.32	1.94	.1647	.0272	.0197	.0075	0.77	.0396	.0008	2.8

Blackstone River at Millville.

YEAR.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
1888,	0.47	-	-	.0444	.0253	-	-	0.44	.0242	.0005	-
1889,	0.38	-	-	.0450	.0277	.0206	.0071	0.48	.0160	.0004	-
1890,	0.34	-	-	.0587	.0211	.0162	.0049	0.46	.0240	.0004	-
1891,	0.32	6.05	1.83	.0807	.0293	.0194	.0099	0.55	.0275	.0005	1.9

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR SIX MONTHS FROM JUNE TO NOVEMBER, INCLUSIVE, OF EACH YEAR FROM 1887 TO 1891.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891,	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0

BLACKSTONE RIVER.

Blackstone River below Sewage Precipitation Works.

[Parts per 100,000.]

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887, . . .	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888, . . .	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889, . . .	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890, . . .	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891, . . .	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2

Blackstone River at Uxbridge.

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887, . . .	0.39	-	-	.1129	.0271	-	-	0.79	.0360	-	-
" " 1888, . . .	0.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	-
" " 1889, . . .	0.32	-	-	.1133	.0296	.0192	.0104	0.66	.0333	.0009	-
" " 1890, . . .	0.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891, . . .	0.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6

Blackstone River at Millville.

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887, . . .	0.31	-	-	.0468	.0220	-	-	0.51	.0210	-	-
" " 1888, . . .	0.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	-
" " 1889, . . .	0.38	-	-	.0499	.0273	.0213	.0060	0.45	.0167	.0003	-
" " 1890, . . .	0.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891, . . .	0.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River, between the Mill Brook Channel and the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6886	Jan. 12	Jan. 13	Decided.	Heavy.	0.6	4.80	1.40	.0560	.0910	.0530	.0380	0.53	.0320	.0010	2.7
6993	Feb. 9	Feb. 10	Decided.	Heavy.	0.3	10.70	3.35	.1440	.1120	.0750	.0370	1.40	.0600	.0022	2.5
7100	Mar. 9	Mar. 11	Decided.	Heavy.	0.0	16.55	1.95	.1600	.1100	.0420	.0680	1.12	.0400	.0041	9.4
7212	Apr. 13	Apr. 14	Decided.	Cons.	0.9	6.60	1.60	.0520	.0360	.0200	.0160	0.66	.0400	.0010	1.6
7302	May 11	May 12	Thick.	Heavy.	0.3	10.30	3.40	.3200	.1240	.0620	.0620	-	.0230	.0040	2.9
7411	June 9	June 10	Decided.	Heavy.	0.8	13.30	4.50	.4800	.2880	.1550	.1330	1.55	.0070	.0003	2.9
7554	July 13	July 14	Thick.	Heavy.	1.8	13.60	5.10	.4080	.1600	.0900	.0700	2.22	.0150	.0000	5.6
7849	Aug. 24	Aug. 25	Decided.	Cons.	1.3	13.60	4.10	.3840	.1760	.1090	.0670	2.10	.0050	.0001	3.9
7928	Sept. 13	Sept. 15	Decided.	Heavy.	1.4	11.70	4.20	.3040	.1050	.0820	.0230	0.90	.0280	.0090	2.3
8055	Oct. 13	Oct. 14	Decided.	Heavy.	0.4	23.70	5.60	.5720	.1340	.0830	.0510	2.60	.0350	.0050	-
8262	Nov. 16	Nov. 17	Thick.	Heavy.	0.9	28.60	10.05	.8000	.3070	.1570	.1500	4.38	.0250	.0080	10.3
8335	Dec. 15	Dec. 16	Decided.	Heavy.	0.9	9.05	2.75	.3280	.2330	.0800	.1530	1.56	.0900	.0035	6.3
Av.	....	....	....	....	0.8	13.54	4.00	.3340	.1563	.0840	.0723	1.73	.0333	.0032	4.6

Odor, offensive. —— The samples were collected from the river about 200 feet below the iron bridge. They were collected on Monday with the exception of Nos. 7411, 8055 and 8335 which were collected on Tuesday, and No. 7928 which was collected on Sunday. The samples were collected between 2.10 and 3.10 P.M., with the exception of No. 7302 which was collected at 11.45 A.M.

Microscopical Examination of Water from the Blackstone River, between Mill Brook Channel and the Worcester Sewage Precipitation Works.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	14	11	-	16	13	9	15	25	16	14	18	16
Number of sample,	6886	6993	7100	7212	7302	7411	7554	7849	7928	8055	8262	8335
PLANTS.												
Diatomaceæ,	4	0	-	7	90	0	0	0	0	0	0	0
Melosira,	0	0	-	0	75	0	0	0	0	0	0	0
Synedra,	4	0	-	7	0	0	0	0	0	0	0	0
Tabellaria,	0	0	-	0	15	0	0	0	0	0	0	0
Algæ. Chlorococcus,	0	0	-	2	0	7	0	5	0	0		

BLACKSTONE RIVER.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Fungi,	0	0	-	0	20	110	472	7	416	150	3,640	800
Beggiatoa,	0	0	-	0	20	0	0	0	0	0	240	800
Molds,	0	0	-	0	0	110	472	7	416	150	0	0
Saccharomyces,	0	0	-	0	0	0	0	0	0	0	3,400	0
ANIMALS.												
Infusoria,	0	0	-	0	5	0	12	25	0	0	350	0
Euglena,	0	0	-	0	0	0	0	20	0	0	0	0
Monas,	0	0	-	0	0	0	12	0	0	0	100	0
Paramæcium,	0	0	-	0	5	0	0	0	0	0	250	0
Trachelomonas,	0	0	-	0	0	0	0	5	0	0	0	0
Vermes. Anurea,	0	0	-	0	0	0	2	0	0	0	0	0
Miscellaneous. Zoöglœa,	1,280	3,856	-	760	11,180	490	2,664	1,105	4,072	3,800	29,400	7,900
TOTAL,	1,284	3,856	-	760	11,295	607	3,150	1,142	4,488	3,950	33,390	8,700

Chemical Examination of Water from the Blackstone River below the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1891.														
6887	Jan. 12	Jan. 13	Decided.	Heavy.	0.70	5.20	1.60	.0640	.0780	.0560	.0220	0.61	.0500	.0010	1.6
6994	Feb. 9	Feb. 10	Distinct.	Slight.	1.30	8.70	3.45	.1360	.1090	.0760	.0330	1.08	.0500	.0020	1.8
7101	Mar. 9	Mar. 11	Decided.	Heavy.	0.00	12.70	2.35	.1240	.1340	.0440	.0900	1.40	.0500	.0041	5.7
7213	Apr. 13	Apr. 14	Decided.	Heavy.	0.70	6.80	2.05	.0720	.0410	.0220	.0190	0.77	.0400	.0010	1.6
7303	May 11	May 12	Thick.	Heavy.	0.50	11.50	3.10	.3600	.1380	.0570	.0810	-	.0100	.0020	3.1
7412	June 9	June 10	Decided	Heavy.	0.80	14.20	5.60	.5200	.1890	.1140	.0750	1.90	.0070	.0003	3.5
7555	July 13	July 14	Thick.	Heavy, black.	1.30	17.20	8.10	.7200	.1340	.0660	.0680	3.20	.0200	.0000	6.7
7848	Aug. 24	Aug. 25	Decided.	Cons.	1.50	19.50	4.90	.8000	.1250	.0900	.0350	3.00	.0000	.0001	6.1
7929	Sept. 13	Sept. 15	Decided.	Heavy.	1.40	11.50	3.80	.3160	.1320	.0670	.0650	1.10	.0280	.0066	3.9
8056	Oct. 13	Oct. 14	Decided	Heavy.	0.50	46.00	16.00	.6640	.1830	.1090	.0740	2.30	.0550	.0100	-
8263	Nov. 16	Nov. 17	Thick.	Heavy.	0.80	25.10	6.20	.8000	.1420	.0840	.0580	4.15	.0300	.0070	10.6
8336	Dec. 15	Dec. 16	Decided.	Heavy.	0.05	9.10	2.15	.3200	.1590	.0490	.1100	1.47	.0900	.0035	5.7
Av.	....	....	....	....	0.80	15.62	4.52	.4080	.1303	.0695	.0608	1.91	.0358	.0031	4.6

Odor, offensive. —— The samples were collected from the river above Millbury and below the point where the effluent from the Worcester sewage precipitation works enters the river. The samples were collected on Monday, with the exception of Nos. 7412, 8056 and 8336 which were collected on Tuesday, and No. 7929 which was collected on Sunday. The samples were collected between 2.00 and 3 15 P.M., except No. 7303 which was collected at 12.00 M.

BLACKSTONE RIVER.

Microscopical Examination of Water from the Blackstone River, below the Worcester Sewage Precipitation Works.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	14	11	-	16	13	9	15	25	16	14	18	16
Number of sample,	6887	6994	7101	7213	7303	7412	7555	7848	7929	8056	8263	8336
PLANTS.												
Diatomaceæ,	**0**	**0**	-	**0**	**0**	**22**	**10**	**0**	**0**	**0**	**0**	**0**
Fragilaria,	0	0	-	0	0	0	10	0	0	0	0	0
Melosira,	0	0	-	0	0	22	0	0	0	0	0	0
Cyanophyceæ. Oscillaria,	**0**	**0**	-	**0**	**0**	**2**	**4**	**0**	**12**	**0**	**0**	**0**
Algæ. Chlorococcus,	**0**	**0**	-	**10**	**0**	**12**	**0**	**15**	**0**	**0**	**0**	**0**
Fungi,	**0**	**0**	-	**7**	**295**	**15**	**100**	**15**	**2,592**	**7,900**	**6,150**	**150**
Beggiatoa,	0	0	-	7	15	0	0	0	0	0	2,200	100
Crenothrix,	0	0	-	0	0	0	0	0	736	0	0	0
Molds,	0	0	-	0	280	15	100	15	1,856	7,900	150	50
Saccharomyces,	0	0	-	0	0	0	0	0	0	0	3,800	0
ANIMALS.												
Infusoria,	**0**	**0**	-	**0**	**10**	**0**	**28**	**2**	**6**	**0**	**150**	**0**
Ciliated infusorian,	0	0	-	0	0	0	0	0	6	0	0	0
Monas,	0	0	-	0	5	0	28	2	0	0	0	0
Paramæcium,	0	0	-	0	5	0	0	0	0	0	150	0
Peridinium,	0	0	-	0	0	0	0	0	0	0	0	0
Vermes,	**0**	**0**	-	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anguillula,	0	0	-	0	5	0	0	0	0	0	0	0
Anurea,	0	0	-	0	5	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**700**	**2,736**	-	**2,560**	**7,920**	**620**	**2,264**	**4,480**	**3,496**	**9,600**	**19,200**	**6,600**
TOTAL,	700	2,736	-	2,577	8,235	671	2,406	4,492	6,106	17,500	25,500	6,750

Chemical Examination of Water from the Blackstone River at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6889	Jan. 13	Jan. 13	Decided.	Cons.	0.50	4.90	1.50	.0880	.0560	.0430	.0130	0.25	.0500	.0012	1.4
6995	Feb. 10	Feb. 10	Decided.	Heavy.	0.70	5.65	1.60	.0520	.0400	.0300	.0100	0.35	.0400	.0005	1.7
7097	Mar. 9	Mar. 11	Distinct.	Slight.	0.20	5.20	1.35	.0600	.0250	.0170	.0080	0.40	.0400	.0005	1.7

BLACKSTONE RIVER.

Chemical Examination — Concluded.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7216	Apr. 14	Apr. 15	Decided.	Cons.	0.40	4.45	0.95	.0560	.0270	.0140	.0130	0.38	.0300	.0005	1.4
7304	May 12	May 12	Decided.	Slight.	0.20	6.95	1.30	.1000	.0550	.0470	.0080	0.52	.0200	.0018	2.5
7413	June 9	June 10	Distinct.	Cons.	0.55	8.50	2.40	.1520	.0110	.0080	.0030	0.73	.0200	.0015	2.2
7556	July 14	July 14	Distinct.	Slight.	0.15	8.80	2.40	.2160	.0330	.0240	.0090	1.18	.0600	.0018	3.6
7838	Aug. 19	Aug. 21	Slight.	Cons.	0.10	4.05	1.90	.1600	.0120	.0060	.0060	0.93	.0600	.0010	3.0
7931	Sept. 15	Sept. 15	Slight.	Slight.	0.40	11.10	2.50	.2000	.0170	.0120	.0050	0.96	.0600	.0002	3.1
8057	Oct. 14	Oct. 14	Distinct.	V. slight.	0.02	13.70	2.40	.4000	.0120	.0050	.0070	1.23	.0300	.0000	4.3
8266	Nov. 17	Nov. 17	V. slight.	Cons.	0.00	14.80	2.85	.2400	.0200	.0150	.0050	1.20	.0250	.0001	5.1
8338	Dec. 16	Dec. 16	Distinct, milky.	Slight.	0.08	11.75	2.15	.2520	.0180	.0150	.0030	1.12	.0400	.0010	4.0
Av.	....	....	....	....	0.27	8.32	1.94	.1647	.0272	.0197	.0075	0.77	.0396	.0008	2.8

Odor, musty and disagreeable, frequently offensive. —— The samples were collected from the canal leading from the upper dam of the Calumet Woollen Company just before the water passes the screens to the wheels.

Microscopical Examination of Water from the Blackstone River, at Uxbridge.

[Number of organisms per cubic centimeter.]

	1891. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	14	11	11	16	13	9	14	21	16	14	18	17
Number of sample,	6889	6995	7097	7216	7304	7413	7556	7838	7931	8057	8266	8338
PLANTS.												
Diatomaceæ,	3	3	0	2	29	3	52	25	88	4	10	1
Asterionella,	0	3	0	0	4	0	0	0	0	0	0	0
Diatoma,	0	0	0	0	4	2	0	2	8	2	3	0
Fragilaria,	0	0	0	0	0	0	6	0	0	0	0	0
Melosira,	3	0	0	0	2	0	15	3	0	0	5	0
Synedra,	0	0	0	1	10	0	31	18	80	0	0	1
Tabellaria,	pr.	0	0	1	9	1	0	2	0	2	2	0
Algæ,	0	0	0	0	15	8	80	46	20	0	pr.	0
Chlorococcus,	0	0	0	0	0	8	72	9	5	0	0	0
Pandorina,	0	0	0	0	0	0	0	18	0	0	0	0
Raphidium,	0	0	0	0	0	0	1	6	0	0	0	0
Scenedesmus,	0	0	0	0	3	0	7	13	14	0	pr.	0
Zoöspores,	0	0	0	0	12	0	pr.	0	1	0	0	0
Fungi. Crenothrix,	0	0	0	0	0	0	0	13	pr.	0	0	0

BLACKSTONE RIVER.

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda. Arcella,	0	0	0	0	0	0	0	0	2	0	0	0
Infusoria,	0	0	0	3	125	0	717	233	222	773	308	32
Dinobryon,	0	0	0	3	108	0	714	148	218	770	308	32
Dinobryon cases,	0	0	0	0	0	0	0	66	0	0	0	0
Euglena,	0	0	0	0	1	0	0	1	1	pr.	0	0
Monas,	0	0	0	0	11	0	pr.	3	1	0	0	0
Paramæcium,	0	0	0	0	0	0	1	0	0	0	0	0
Peridinium,	0	0	0	0	0	0	2	14	1	0	pr.	pr.
Synura,	0	0	0	0	3	0	0	pr.	0	2	0	0
Trachelomonas,	0	0	0	0	2	0	pr	1	1	1	0	0
Vermes. Anurea,	0	0	0	0	1	0	pr.	1	0	1	0	0
Miscellaneous. Zoöglœa,	1,752	888	1,212	3,320	908	108	742	360	490	64	98	228
TOTAL,	1,755	891	1,212	3,325	1,078	119	1,591	678	822	842	416	261

Chemical Examination of Water from the Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
6897	Jan. 15	Jan. 16	Distinct.	Slight.	0.60	4.00	1.25	.0262	.0218	.0190	.0028	.22	.0300	.0004	1.1
6997	Feb. 11	Feb. 12	Slight.	Slight.	0.30	3.85	0.90	.0320	.0262	.0190	.0072	.38	.0200	.0006	1.4
7117	Mar. 13	Mar. 13	Slight.	Slight.	0.35	3.20	0.90	.0120	.0134	.0110	.0024	.20	.0400	.0002	1.4
7217	Apr. 14	Apr. 15	Decided.	Cons.	0.35	3.70	1.05	.0272	.0220	.0140	.0080	.28	.0200	.0003	1.3
7319	May 13	May 14	Distinct.	Cons.	0.25	4.75	1.40	.0640	.0172	.0132	.0040	.41	.0200	.0003	1.8
7421	June 9	June 10	Distinct.	Cons.	0.30	6.00	1.75	.1080	.0320	.0220	.0100	.49	.0200	.0015	1.4
7563	July 14	July 15	Distinct.	Cons.	0.25	6.50	1.75	.1120	.0220	.0090	.0130	.98	.0350	.0005	1.9
7831	Aug. 19	Aug. 20	Slight.	Slight.	0.20	6.00	1.50	.0432	.0192	.0154	.0038	.44	.0350	.0005	2.1
7943	Sept. 16	Sept 17	V. slight.	Slight.	0.30	9.00	3.50	.1224	.0204	.0172	.0032	.79	.0550	.0003	2.5
8138	Oct. 17	Oct. 17	Slight.	Slight.	0.25	8.10	2.80	.1328	.0160	.0142	.0018	.78	.0250	.0005	2.6
8267	Nov. 18	Nov. 18	Distinct.	Slight.	0.14	9.30	2.80	.1448	.1208	.0628	.0580	.84	.0150	.0001	3.0
8360	Dec. 19	Dec. 19	Distinct.	Slight.	0.50	8.25	2.40	.1440	.0200	.0160	.0040	.74	.0150	.0010	2.5
Av.	....	....	....	....	0.32	6.05	1.83	.0807	.0293	.0194	.0099	.55	.0275	.0005	1.9

Odor, generally musty, sometimes disagreeable or offensive.——The samples were collected from the river just above the dam in the village of Millville.

BLACKSTONE RIVER.

Microscopical Examination of Water from the Blackstone River at Millville, Blackstone.

[Number of organisms per cubic centimeter.]

	1891.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	14	14	16	16	10	15	20	17	17	20	22
Number of sample,	6897	6997	7117	7217	7319	7421	7563	7831	7943	8138	8267	8360
PLANTS.												
Diatomaceæ,	2	5	4	42	117	26	46	3	59	26	40	17
Asterionella,	0	0	0	2	17	0	1	0	0	6	7	17
Diatoma,	0	0	2	28	48	3	2	1	2	1	7	0
Fragilaria,	0	0	0	0	0	0	0	0	0	8	0	0
Melosira,	0	0	0	0	3	0	0	0	0	3	0	0
Navicula,	0	pr.	0	2	1	0	0	0	2	3	pr.	0
Synedra,	2	pr.	pr.	6	44	21	40	pr.	47	2	14	0
Tabellaria,	0	5	2	4	4	2	3	2	8	3	12	0
Cyanophyceæ. Chroöcoccus,	0	0	0	0	0	0	8	0	0	0	0	8
Algæ,	0	0	0	5	4	14	10	21	21	2	3	pr.
Chlorococcus,	0	0	0	0	0	14	4	2	6	1	2	pr.
Desmidium,	0	0	0	0	0	0	0	0	6	0	0	0
Pandorina,	0	0	0	0	0	pr.	0	16	0	0	0	0
Scenedesmus,	0	0	0	0	2	pr.	4	1	7	1	1	0
Staurastrum,	0	0	0	1	0	0	2	2	0	0	0	0
Zoöspores,	0	0	0	4	2	0	0	0	2	0	0	0
Fungi. Crenothrix,	16	0	pr.	3	9	1	128	148	168	40	1	0
ANIMALS.												
Rhizopoda. Actinophrys,	0	0	0	0	0	0	pr.	1	0	0	0	0
Infusoria,	1	0	2	7	72	39	290	285	77	123	354	0
Cryptomonas,	0	0	0	0	5	0	0	0	0	0	pr.	0
Dinobryon,	0	0	0	6	63	38	288	276	51	118	346	0
Dinobryon cases,	0	0	0	0	0	0	0	0	0	3	7	0
Euglena,	0	0	0	0	0	0	0	1	1	0	0	0
Glenodinium,	0	0	0	0	0	0	1	1	0	0	0	0
Monas,	0	0	0	0	pr.	1	0	pr.	15	pr.	pr.	0
Paramæcium,	0	0	0	0	2	0	0	0	0	1	0	0
Peridinium,	1	0	2	0	0	0	pr.	6	pr.	0	pr.	0
Synura,	0	0	0	0	1	0	0	0	0	1	pr.	0
Trachelomonas,	0	0	0	1	1	0	1	1	2	0	1	0
Uroglena volvox,	0	0	0	0	0	0	0	0	8	0	0	0
Vermes. Anurea,	0	0	0	0	1	0	pr.	0	pr.	0	0	0
Crustacea. Cyclops,	0	0	0	0	0	0	pr.	0	0	0	0	0
Miscellaneous. Zoöglœa,	1,176	1,044	270	1,696	550	128	256	152	244	32	348	140
TOTAL,	1,195	1,049	276	1,753	753	208	738	610	569	223	746	165

SPECIAL EXAMINATION OF THE BLACKSTONE RIVER AND WORCESTER SEWAGE PRECIPITATION WORKS, IN JULY, 1891.

This examination was made during a very dry part of the summer of 1891 and was continued day and night during the week ending July 29. It included chemical, and in many cases microscopical, examinations of water from the river at several points and from its principal tributaries; chemical examinations of sewage and effluent from the Worcester precipitation works; and measurements of the flow of the river, of sewage turned directly into the river, and of sewage treated at the precipitation works.

Special precautions were taken to obtain samples which would accurately represent the *average* character of the sewage, effluent and river water. In the case of the sewage one bottle was filled for chemical analysis every six hours, but instead of filling it wholly at one time its contents were made up of twelve equal half-hourly collections. The number of analyses of sewage made during the week was 28, representing in all 336 portions of sewage. The same number of samples of effluent were collected and in the same way, but as the amount of sewage then being treated required six hours for its passage through the tanks the samples of effluent were taken six hours later than the corresponding samples of sewage. The samples of sewage were collected from the mouth of the main sewer above the screens and above the point where the chemicals are mixed with the sewage, and the samples of effluent from the weir where the sewage flowed from the last tank.

In collecting the samples from the river above and below the precipitation works the same general plan was followed as in the collection of the sewage and effluent, except that three samples instead of four were collected each twenty-four hours and they were made up of only two or three equal portions. From other points on the river and its tributaries only one sample a day was collected, but wherever it was feasible this sample was made up of from two to four equal portions. The total number of samples analyzed in connection with this examination was 136.

The sewage of Worcester is unusual in its character, owing to the large amount of manufacturing drainage contained in it, much of which is from iron and wire works where large quantities of acid are used. Owing to the intermittent way in which the drainage from

BLACKSTONE RIVER.

these establishments is discharged, the character of the sewage is very variable and at times it contains a large amount of iron salts (mainly sulphate of iron), and may also contain free acid.

There are six tanks at the precipitation works, each 100 feet long, 66.67 feet wide and 7 feet deep measuring from the top of the walls. At the time of the special examination the amount of sewage treated was 6,010,000 gallons per day and the depth of the sewage in the tanks was about 6½ feet.

The sewage on its way to the tanks passes through screens and is then mixed with chemicals, after which it passes through a mixing channel to the first tank and then continuously through the whole series of tanks, and is discharged over a weir at the outlet of the last one. The chemicals used are lime and sulphate of alumina. When sulphate of iron is present in the sewage in sufficient amount to form a satisfactory precipitate with the lime, no sulphate of alumina is required. The method of treatment has been varied from time to time in accordance with the information gained by continued experiments at the works. At the time of the special examination the lime, which was reduced to a fine powder at the works, and the sulphate of alumina, also in the form of powder, were turned through hoppers into agitators and there thoroughly mixed with a small amount of crude sewage, which was lifted by means of a centrifugal pump to the top of the agitators. From the agitators the chemicals mixed with this small amount of sewage were discharged into the main body of sewage at the head of the mixing channel. There are two sets of agitators, one for the lime and one for the sulphate of alumina. They are upright wooden vats of 1,600 gallons capacity, containing revolving arms, driven by machinery.

When the sewage contained large quantities of iron it was treated with correspondingly large amounts of lime. After the iron stopped coming no more chemicals were used for several hours, the sewage already in the tanks being relied upon to cause the precipitation of that which followed. The precipitation which takes place in this case is doubtless due to the large amount of flocculent iron oxide contained in the sewage first treated, and to a rotary motion of the whole body of sewage in the first tank, caused by the high velocity of the stream entering it, whereby a part of this sewage remains in the tank and is mingled with that which follows, instead of being pushed out ahead of it. After the precipitating power of the iron in

the tanks was exhausted, lime and sulphate of alumina were used, unless the sewage then coming contained iron, in which case lime only was used.

Later in the season the method of adding the lime to the sewage was changed, and it is now thoroughly slaked and added to the sewage in the form of milk of lime.*

The amount of chemicals used during the week when the special examination was made is as follows: —

Lime, ...	33.66 tons of 2,000 lbs each.
Sulphate of alumina, ...	7.11 tons of 2,000 lbs. each.

This amount of chemicals is more than the average amount used per week, which may have been due in part to the occurrence of some showers. The quantities above given are equal to 1,600 pounds of lime and 340 pounds of sulphate of alumina, making a total of 1,940 pounds of chemicals, per million gallons of sewage. The average amount of sewage treated during the year was 3,833,000 gallons per day. The average amount of chemicals used during the year was 1,080 pounds of lime and 90 pounds of sulphate of alumina per million gallons of sewage. It should be borne in mind that these quantities of chemicals are used with the dilute sewage flowing in the Mill Brook channel. If the sewage should be concentrated by keeping it separate from the brook water the amount of chemicals required per million gallons would undoubtedly be much larger.

The analyses made in connection with the special examination were more complete than usual. The residue on evaporation was determined both before and after filtration through filter paper; the amount of oxygen consumed from permanganate, and the iron oxide, lime and sulphuric acid were also determined. In a few instances the determinations of oxygen consumed and of the other constituents above mentioned were not made with each individual sample, but the average amount was determined after mixing equal parts of all samples collected at the same point. These instances will be found noted in the tables where they appear. A series of bacteriological

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* A full discussion of the subject of the chemical precipitation of sewage, by Allen Hazen, giving the results obtained with different precipitants at the Lawrence Experiment Station, is contained in the special report of the State Board of Health on the Purification of Sewage and Water, 1890.

examinations of the sewage and effluent, and of the river water at Worcester and Millbury was made, though not until September.

The detailed results of the special examination will be found in a series of tables beginning on page 277, and only the general results will be referred to here.

The volume flowing in the different channels during the week is given in the table on page 277 and also on the diagram on page 257. The average amount of sewage flowing in the Mill Brook channel was 12,610,000 gallons per day, of which 6,600,000 gallons were discharged directly into the river without treatment, and 6,010,000 gallons were treated at the precipitation works. These figures do not represent the proportion of sewage treated throughout the year, because, as before stated, the average amount of sewage treated was much less, and during the wetter portions of the year there is a still larger volume of dilute sewage flowing in the Mill Brook channel and requiring treatment. During the week when the special examination was made, the flow of the river above the Mill Brook channel averaged 23,230,000 gallons per day, which was about twice the total volume of the Mill Brook sewage and somewhat less than four times the volume of that portion of this sewage discharged in a crude state into the river.

From these statements of the relative amount of river water and of untreated sewage discharged directly into the stream, it is obvious that the river would be very foul even if the portion treated by the process of chemical precipitation was rendered wholly pure. The table on the opposite page gives in a condensed form the results obtained by the chemical treatment of the sewage during the week of the special examination. The amount of sewage treated, as already stated, was 6,010,000 gallons per day, which is a somewhat larger quantity than can be treated at the present works with the greatest efficiency; but it is also proper to call attention to the fact that the amount of chemicals used per million gallons was considerably in excess of the average amount used throughout the year.

BLACKSTONE RIVER.

Comparison of Analyses of Sewage and Effluent from the Worcester Precipitation Works during the Week ending July 29, 1891.

[Parts per 100,000.]

	Sewage.	Effluent.	Per cent. decrease or increase.
Color,	0.28	0.14	50 decrease.
Residue on evaporation, —			
Total,	92.86	52.65	43 decrease.
Dissolved,	44.13	46.64	6 increase.
Suspended,	48.73	6.01	88 decrease.
Loss on ignition,	28.31	12.60	56 decrease.
Dissolved,	13.29	11.28	15 decrease.
Suspended,	15.02	1.32	91 decrease.
Fixed residue,	64.55	40.05	38 decrease.
Dissolved,	30.84	35.36	15 increase.
Suspended,	33.77	4.69	86 decrease.
Free ammonia,	1.2684	1.1829	7 decrease.
Albuminoid ammonia,	.4509	.1994	56 decrease.
Dissolved,	.1510	.1588	5 increase.
Suspended,	.2999	.0406	86 decrease.
Chlorine,	5.33	4.77	11 decrease.
Nitrogen as nitrates,	.0575	.0542	6 decrease.
Nitrogen as nitrites,	.0103	.0562	446 increase.
Oxygen consumed, —			
Unfiltered,	4.9126	1.0583	78 decrease.
Filtered,	1.5728	.8116	48 decrease.
Iron oxide (Fe_2O_3),	10.75	0.41	96 decrease.
Lime, (CaO),	3.33	12.74	283 increase.
Sulphuric acid (SO_3),	14.84	15.66	6 increase.
Bacteria per cubic centimeter,	209,592	14,458	93 decrease.

NOTE. — The bacteriological examinations were made Sept. 15, 1891. The number of bacteria in the sewage, as above given, is the average of two determinations made with samples of ordinary sewage. One sample, collected when there was much iron in the sewage, contained only 18,900 bacteria per cubic centimeter. This sample was very much infested with molds. The number of bacteria in four samples of effluent varied from 9,016 to 20,882. The gelatine plates of all of these samples were prepared on the spot, immediately after taking the samples.

The object of sewage purification is for the most part the removal of the organic matter. This is shown in the table by a reduction of the loss on ignition, of the albuminoid ammonia and of the oxygen

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consumed. Using the loss on ignition as a basis it will be seen that the dissolved matter was reduced by precipitation 15 per cent. and the suspended matter 91 per cent., or, taking both together, there was a reduction of 56 per cent. If we take the total albuminoid ammonia as a basis, the reduction is the same as with the loss on ignition, viz., 56 per cent. There is, however, in this case an increase of 5 per cent. in the dissolved matter and a reduction of 86 per cent. in the portion suspended in the water. In the case of the oxygen consumed there is a reduction of 78 per cent. in the unfiltered and 48 per cent. in the filtered samples. There is a noticeable increase in nitrites, showing a partial oxidation of a small portion of the nitrogenous organic matter. The amount of lime added to the sewage and remaining in the effluent and the corresponding diminution by precipitation of iron oxide are clearly shown.

The effect of the discharge of sewage and sewage effluent upon the river water is shown by the following table which contains the average analyses for a week of the water of the river at three points, viz.: above the Mill Brook channel, between the Mill Brook channel and the precipitation works, and below the precipitation works.

Comparison of Analyses, made during the Week ending July 29, 1891, of the Water of the Blackstone River above and below the Points where the Worcester Sewage and Sewage Effluent are Discharged.

[Parts per 100,000.]

	Above Mill Brook Channel.	Between Mill Brook Channel and the Precipitation Works.	Below the Precipitation Works.
Color,	0.95	.44	.33
Residue on evaporation,—			
Total,	6.94	27.84	35.89
Dissolved,	-	16.71	23.69
Suspended,	-	11.13	12.20
Loss on ignition,	2.58	8.37	9.55
Dissolved,	-	5.19	5.86
Suspended,	-	3.18	3.69
Fixed residue,	4.36	19.47	26.34
Dissolved,	-	11.52	17.83
Suspended,	-	7.95	8.51

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Comparison of Analyses, etc. — Concluded.

[Parts per 100,000.]

	Above Mill Brook Channel.	Between Mill Brook Channel and the Precipitation Works.	Below the Precipitation Works.
Free ammonia,	.0166	.2699	.6233
Albuminoid ammonia,	.0489	.1168	.1869
Dissolved,	.0318	.0415	.0780
Suspended,	.0171	.0753	.1089
Chlorine,	.27	1.67	2.48
Nitrogen as nitrates,	.0117	.0134	.0115
Nitrogen as nitrites,	.0001	.0026	.0052
Oxygen consumed, —			
Unfiltered,	.7030	1.3241	1.7809
Filtered,	-	.4246	.6606
Iron oxide (Fe_2O_3),	0.36	4.45	3.52
Lime (CaO),	0.77	1.60	4.33
Sulphuric acid (SO_3),	0.80	5.39	7.62
Bacteria per cubic centimeter,	77,750	47,550	16,650

NOTE. — The bacteriological examinations were made Sept. 15, 1891, and are in each case the average of two determinations. All of the samples contained quite a number of molds.

These three points are all included within a distance of but little more than a mile. The chemical analysis of water at the upper station shows it to be somewhat polluted by the sewage and manufacturing refuse which enter it at different points along its course, but the water is not sufficiently polluted to be in any way objectionable to those living near the river. The very great increase in the amount of pollution at the lower points is so clearly shown by nearly every determination given in the table that comment is unnecessary. The third column of this table may be said to represent the analysis of the river water at the point where the water is in the foulest condition, though it does not necessarily follow that the most offensive portion of the river is exactly at this place, because the deposits which accumulate on the bed and banks of the stream and in the mill ponds below may be more offensive than the water itself, particularly when they are exposed by the lowering of the river in dry weather.

In the table on the next page the analysis of this most polluted portion of the river is repeated in the first column, and in the succeeding columns may be seen the corresponding analyses at points further down the stream.

BLACKSTONE RIVER.

Comparison of Analyses made during the Week ending July 29, 1891, of the Water of the Blackstone River, from a Point just below the Precipitation Works at Worcester to Millville. This Table represents the portion of the River where the Pollution of the Water is Decreasing as the Distance from Worcester Increases.

[Parts per 100,000.]

	Below Precipitation Works, Worcester.	Outlet of Morse's Mill Pond, Millbury.	Below Last Dam in Millbury.	Dam of Calumet Woollen Co., Uxbridge.	Above Dam at Millville.
Area of water-shed (square miles),	64.6	70.6	83.9	145.9	258.1
Relative sizes of water-sheds,	1.00	1.09	1.30	2.26	4.00
Color,	.33	.10	.10	.24	.26
Residue on evaporation,—					
Total,	35.89	28.50	20.60	11.07	7.49
Dissolved,	23.69	23.20	16.00	-	-
Suspended,	12.20	5.30	4.60	-	-
Loss on ignition,	9.55	7.50	3.80	2.59	2.49
Dissolved,	5.86	5.10	2.40	-	-
Suspended,	3.69	2.40	1.40	-	-
Fixed residue,	26.34	21.00	16.80	8.48	5.00
Dissolved,	17.83	18.10	13.60	-	-
Suspended,	8.51	2.90	3.20	-	-
Free ammonia,	.6233	.6070	.5010	.2506	.0673
Albuminoid ammonia,	.1869	.1060	.0590	.0345	.0214
Dissolved,	.0780	.0420	.0280	.0271	.0163
Suspended,	.1089	.0640	.0310	.0074	.0051
Chlorine,	2.48	2.85	1.71	0.87	0.52
Nitrogen as nitrates,	.0115	.0060	.0070	.0443	.0359
Nitrogen as nitrites,	.0052	.0000	.0001	.0004	.0002
Oxygen consumed, —					
Unfiltered,	1.7809	1.0455	.5830	.1330	.4270
Filtered,	.6606	.5030	.4705	.1170	.2730
Iron oxide (Fe_2O_3),	3.52	3.87	1.00	0.17	0.12
Lime (CaO),	4.33	4.39	3.63	1.99	1.12
Sulphuric acid (SO^3),	7.62	9.30	7.19	3.43	1.75
Bacteria per cubic centimeter,	16,650	84,600	-	-	-

NOTE. — The bacteriological examinations were made Sept. 15, 1891, and are in each case the average of two determinations.

This table shows the improvement in the quality of the water caused by dilution with the cleaner water from the various tributaries, by the subsidence of suspended matters, and by decomposition or oxidation. The relative flow at different points on the river is roughly proportional to the corresponding watersheds; the area of these watersheds is therefore given in the first line of the table and their relative sizes in the second line. If we assume that the figures in the second line represent accurately the relative volumes flowing, there would be a dilution of only 9 per cent. at Morse's mill pond in the upper part of Millbury, and 30 per cent. at a point just below the last dam in Millbury. At Millville each gallon of polluted water which passed the precipitation works would be diluted by the addition of three gallons of comparatively pure water.

One of the noticeable features of the table is the decrease in the amount of suspended matter as the water flows from the point below the precipitation works to Millbury; for instance, the suspended residue on evaporation decreases from 12.20 parts per 100,000 to 5.30 parts. This is obviously due to the deposition of suspended matter. There is practically no decrease in the dissolved residue.

The total albuminoid ammonia decreases from .1869 parts per 100,000 to .1060 parts in this same distance, and below Millbury it is further reduced to .0590 parts. The free ammonia (which is a product of decay in solution) decreases very little in the upper portion of the river, showing that the reduction due to dilution and decomposition is to a considerable extent offset by the further decomposition of the organic matter contained in the water or deposited upon the bed of the stream.

The purification of the river by the oxidation of the nitrogenous organic matter to nitrates is only noticeable at the two lower stations. The amount of iron shows a slight increase as the water passes from below the precipitation works to Morse's millpond at Millbury. This is probably due to the fact that the analyses are not strictly comparable, that at the upper station representing the average of day and night samples covering a whole week, while that at the lower station represents the average of samples collected in the day time on two days only. At points further down stream there is a very

great reduction in the amount of iron, which is probably due to its precipitation as oxide. There is no change in the amount of lime and sulphuric acid contained in the water which cannot be attributed to dilution.

Analyses were made in 1872, 1875 and 1881 of the water of the Blackstone River at Millbury, the samples being taken either from Morse's millpond or from some other point on the river above Singletary Brook where the character of the water would be practically the same as in the millpond. These analyses are given in comparison with those made during the special examination in the following table, and show clearly the great increase which has taken place in the amount of polluting matter in the river during the past sixteen years.

Comparison of Analyses of Water from the Blackstone River in Millbury, above Singletary Brook, made in 1872, 1875, 1881 and 1891.

[Parts per 100,000.]

	Nov. 8, 1872.	July, 1875.	Average of two Analyses, Aug. 30 and Oct. 2, 1881.	Average of two Analyses, July 24 and 25, 1891.
Total residue on evaporation,	6.20	8.04	13.15	28.50
Loss on ignition,	-	-	3.35	7.50
Fixed residue,	-	-	9.80	21.00
Free ammonia,	.0450	.0092	.0793	.6070
Albuminoid ammonia,	.0400	.0307	.1176	.1060
Chlorine,	1.20	0.92	2.40	2.85

NOTE.—The sample analyzed in 1872 was collected just after a heavy rain which had greatly increased the flow of the river.

BLACKSTONE RIVER.

The tables which follow give in detail the results of measurements and analyses made during the week beginning July 22, 1891.

Average Daily Flow of Sewage, Sewage Effluent and River Water at Worcester during the Week beginning at 8 A.M., July 22, 1891.

[Cubic feet per second.]

Twenty-four Hours, Beginning at 8 A.M.	Sewage discharged directly into river at mouth of Mill Brook.	Sewage discharged into river through by-pass at precipitation works.	Total sewage discharged into river without treatment.	Sewage effluent discharged into river from precipitation works.	Flow of Mill Brook just above point where sewage is diverted.	Flow of river just above Mill Brook.	Flow of river between Mill Brook and precipitation works.	Flow of river below precipitation works.
1891.								
Wednesday, July 22,	12.00	1.98	13.98	9.04	23.02	28.48	40.48	51.50
Thursday, " 23,	12.16	0.72	12.88	9.41	22.29	41.71	53.87	64.00
Friday, " 24,	12.59	1.52	14.11	9.46	23.57	51.62	64.21	75.19
Saturday, " 25,	10.35	1.22	11.57	8.84	20.41	42.93	53.28	63.34
Sunday, " 26,	0.64	1.48	2.12	9.20	11.32	23.25	23.89	34.57
Monday, " 27,	3.73	5.40	9.13	9.69	18.82	23.63	27.36	42.45
Tuesday, " 28,	4.80	2.78	7.58	9.50	17.08	39.95	44.75	57.03
Average,	8.04	2.16	10.20	9.30	19.50	35.94	43.98	55.44
Average in million gallons per day,	5.20	1.40	6.60	6.01	12.61	23.23	28.43	35.84

BLACKSTONE RIVER.

Chemical Examination of Worcester Sewage

[Parts per 100,000.]

	Number.	Date of Collection. 1891.	Date of Examination. 1891.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dissolved.	Total Residue. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Loss on Ignition. Suspended.
		July.	July.									
1	7589	22, 8 A.M. to 2 P.M.	23	Decided, milky.	V. heavy.	0.20	76.60	54.60	22.00	30.20	16.00	14.20
2	7595	22, 2 P.M. to 8 P.M.	24	Decided, milky.	V. heavy.	0.10	78.60	46.40	32.20	33.80	18.20	15.60
3	7600	22-23, 8 P.M. to 2 A.M.	24	Distinct.	V. heavy.	0.15	83.40	75.40	8.00	25.20	19.60	5.60
4	7607	23, 2 A.M. to 8 A.M.	24	Distinct.	Cons.	0.05	60.00	36.40	23.60	21.00	13.40	7.60
5	7602	23, 8 A.M. to 2 P.M.	24	Decided.	V. heavy.	0.20	82.40	51.60	30.80	37.20	15.00	22.20
6	7617	23, 2 P.M. to 8 P.M.	25	Distinct.	V. heavy.	0.15	59.60	41.00	18.60	25.80	9.40	16.40
7	7619	23-24, 8 P.M. to 2 A.M.	25	Distinct.	V. heavy.	0.20	68.80	58.80	10.00	20.80	19.20	1.60
8	7624	24, 2 A.M. to 8 A.M.	25	Decided.	V. heavy.	0.00	57.20	39.60	17.60	17.60	9.00	8.60
9	7636	24, 8 A.M. to 2 P.M.	26	Decided.	V. heavy.	0.35	77.80	39.20	38.60	35.80	15.20	20.60
10	*7649	24, 2 P.M. to 8 P.M.	26	Decided.	V. heavy.	-	522.40	33.00	489.40	114.00	5.40	108.60
11	7648	24-25, 8 P.M. to 2 A.M.	26	Distinct.	V. heavy.	0.10	107.40	60.40	47.00	29.80	23.60	6.20
12	7650	25, 2 A.M. to 8 A.M.	26	Decided.	Heavy, rusty.	0.00	52.00	31.40	20.60	15.40	8.00	7.40
13	7657	25, 8 A.M. to 2 P.M.	27	Decided.	V. heavy.	0.30	63.80	35.80	28.00	22.60	11.20	11.40
14	7660	25, 2 P.M. to 8 P.M.	28	Decided.	V. heavy.	0.30	93.40	42.40	51.00	30.40	9.60	20.80
15	7667	25-26, 8 P.M. to 2 A.M.	28	Distinct.	V. heavy.	0.20	85.00	72.60	12.40	32.00	23.80	8.20
16	7668	26, 2 A.M. to 8 A.M.	28	Decided.	Heavy, black.	0.30	56.60	23.00	33.60	9.60	6.00	3.60
17	7666	26, 8 A.M. to 2 P.M.	28	Decided.	V. heavy.	0.80	173.60	27.80	145.80	33.20	6.40	26.80
18	7670	26, 2 P.M. to 8 P.M.	28	Decided.	Heavy, black.	1.00	84.00	26.00	58.00	19.20	9.40	9.80
19	7682	26-27, 8 P.M. to 2 A.M.	28	Slight.	Heavy, dark.	1.00	52.80	28.00	24.80	16.40	7.00	9.40
20	7686	27, 2 A.M. to 8 A.M.	29	Slight.	Cons.	0.25	51.80	24.80	27.00	12.00	7.00	5.00
21	7688	27, 8 A.M. to 2 P.M.	29	Decided.	V. heavy.	0.90	112.80	37.00	75.80	39.60	7.00	32.60
22	7700	27, 2 P.M. to 8 P.M.	29	Decided.	V. heavy.	0.10	98.80	53.60	45.20	36.60	20.80	15.80
23	7702	27-28, 8 P.M. to 2 A.M.	29	Slight.	V. heavy.	0.20	80.80	58.00	22.80	32.20	21.20	11.00
24	7705	28, 2 A.M. to 8 A.M.	29	Distinct.	Cons.	0.00	50.40	36.80	13.60	17.80	15.20	2.60
25	7715	28, 8 A.M. to 2 P.M.	30	Decided.	V. heavy.	0.25	63.60	47.00	16.60	14.40	14.00	.40
26	7708	28, 2 P.M. to 8 P.M.	29	Decided.	V. heavy.	0.15	73.60	44.40	29.20	31.00	14.00	17.00
27	7718	28-29, 8 P.M. to 2 A.M.	30	Distinct.	V. heavy.	0.25	83.60	71.20	12.40	23.40	17.80	5.60
28	7723	29, 2 A.M. to 8 A.M.	30	Distinct.	Heavy, rusty.	0.05	49.20	39.40	9.80	15.60	9.80	5.80
29	Av.	....	......	....	....	0.28	92.86	44.13	48.73	28.31	13.29	15.02

Averages of the above

		Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
30	For the 24 hours beginning at 8 A.M., Wednesday, July 22,	0.13	74.65	53.20	21.45	27.55	16.80	10.75
31	For the 24 hours beginning at 8 A.M., Thursday, July 23,	0.14	67.00	47.75	19.25	25.35	13.15	12.20
32	For the 24 hours beginning at 8 A.M., Friday, July 24, .	0.15	189.90	41.00	148.90	48.75	13.05	35.70
33	For the 24 hours beginning at 8 A.M., Saturday, July 25,	0.27	74.70	43.45	31.25	23.65	12.65	11.00
34	For the 24 hours beginning at 8 A.M., Sunday, July 26, .	0.76	90.55	26.65	63.90	20.20	7.45	12.75
35	For the 24 hours beginning at 8 A.M., Monday, July 27, .	0.30	85.70	46.35	39.35	31.55	16.05	15.60
36	For the 24 hours beginning at 8 A.M., Tuesday, July 28,	0.18	67.50	50.50	17.00	21.10	13.90	7.20
37	Average, ...	0.28	92.86	44.13	48.73	28.31	13.29	15.02

Averages of Samples collected

		Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
38	For the hours from 8 A.M. to 2 P.M., ...	0.43	92.94	41.86	51.08	30.43	12.11	18.32
39	For the hours from 2 P.M. to 8 P.M., ...	0.30	144.34	40.97	103.37	41.54	12.40	29.14
40	For the hours from 8 P.M. to 2 A.M., ...	0.30	80.26	60.63	19.63	25.69	18.89	6.80
41	For the hours from 2 A.M. to 8 A.M., ...	0.09	53.89	33.06	20.83	15.57	9.77	5.80
42	Average, ...	0.28	92.86	44.13	48.73	28.31	13.29	15.02

* No. 7649 was an abnormal sample containing a great amount of suspended matter which rendered it opaque. As its color, on the scale used, could not be determined, the average color is that of the remaining twenty seven samples.

BLACKSTONE RIVER.

collected just above the Precipitation Works.

[Parts per 100,000.]

Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (CaO).	Sulphuric Acid (SO_3).	
1.5500	.6880	.2660	.4220	7.60	.0500	.0166	5.8140	2.3320	12.08	3.00	17.73	1
1.0900	.6000	.1860	.4140	7.55	.0500	.0220	4.8730	1.5990	9.63	3.50	14.03	2
1.0100	.3700	.1380	.2320	6.35	.0050	.0046	4.1320	2.5660	16.40	2.78	26.00	3
.4900	.1280	.0340	.0940	3.05	.1400	.0035	2.7070	1.8990	15.14	1.58	20.88	4
1.6700	.7220	.2580	.4640	6.40	.0500	.0105	6.3390	1.7990	11.04	3.00	16.62	5
1.2340	.5060	.1640	.3420	6.85	.0090	.0320	4.8480	1.7410	8.10	2.52	13.17	6
.9840	.3120	.1240	.1880	5.42	.0850	.0040	4.7310	2.7980	14.86	2.96	25.21	7
.4900	.1160	.0360	.0800	3.20	.1250	.0100	2.6910	1.1830	11.41	3.98	16.58	8
1.9640	.7400	.2580	.4820	6.45	.0090	.0000	6.6340	2.4590	8.84	2.64	13.50	9
.9640	.9400	.0900	.8500	5.00	.0070	.0000	20.7420	1.9330	32.11	5.56	8.93	10
.9440	.3160	.1060	.2100	4.60	.0750	.0070	4.3650	2.7060	14.77	3.14	23.34	11
.5640	.0880	.0300	.0580	2.70	.1000	.0080	1.8660	.9990	9.43	2.66	12.71	12
1.3300	.5400	.2040	.3360	5.45	.0500	.0105	5.0680	1.8830	7.61	3.04	11.37	13
1.1200	.5740	.1780	.3960	5.75	.0100	.0000	6.7300	.5930	11.22	3.80	14.33	14
1.2000	.3120	.1600	.1520	6.36	.0600	.0105	5.5680	1.0180	18.71	3.26	27.12	15
.9300	.2060	.0680	.1380	4.85	.0150	.0500	1.8990	.5110	3.58	3.28	4.78	16
2.7500	.9100	.2500	.6600	5.60	.0100	.0000	6.9640	1.3020	8.13	3.50	4.66	17
2.8200	.4860	.2060	.2800	6.78	.0070	.0000	5.1110	1.3990	3.92	3.10	4.27	18
1.9200	.3160	.1020	.2140	5.15	.0150	.0500	1.8910	.4480	2.00	3.30	3.67	19
.8400	.1480	.0460	.1020	3.20	.2000	.0105	.8260	.3750	1.52	3.12	3.28	20
2.4600	.9780	.3260	.6520	6.70	.0070	.0000	7.6370	1.6890	5.77	4.16	8.38	21
1.2100	.5460	.1780	.3680	7.70	.0300	.0105	5.4500	2.1230	9.63	3.64	15.88	22
.9600	.2880	.1180	.1700	4.65	.0070	.0020	1.9420	.6230	11.81	2.80	20.51	23
.4600	.1040	.0360	.0680	3.70	.1250	.0050	1.4490	.7430	7.78	2.64	14.44	24
1.6200	.6220	.2500	.3720	4.85	.0700	.0080	5.2890	2.5860	8.82	3.72	16.02	25
1.1900	.5300	.1960	.3340	5.20	.0600	.0050	5.7580	.6230	9.56	2.52	13.81	26
1.1500	.3700	.1740	.1960	5.65	.0900	.0015	4.2400	2.7890	16.06	6.14	27.92	27
.6000	.1700	.0460	.1240	2.40	.1500	.0070	1.9690	1.3190	11.12	3.98	16.41	28
1.2684	.4509	.1510	.2999	5.33	.0575	.0103	4.9126	1.5728	10.75	3.33	14.84	29

Samples by Days.

1.0350	.4465	.1560	.2905	6.14	.0612	.0117	4.3815	2.0990	13.31	2.71	19.66	30
1.0945	.4140	.1455	.2685	5.47	.0672	.0141	4.6522	1.8802	11.35	3.11	17.89	31
1.1090	.5210	.1210	.4000	4.69	.0477	.0037	8.4017	2.0242	16.29	3.50	14.62	32
1.1450	.4080	.1525	.2555	5.60	.0337	.0177	4.8162	1.0012	10.28	3.34	14.40	33
2.0625	.4650	.1510	.3140	5.18	.0580	.0151	3.6980	0.8810	3.89	3.25	3.97	34
1.2725	.4790	.1645	.3145	5.69	.0422	.0044	4.1195	1.2945	8.75	3.31	14.80	35
1.1400	.4230	.1665	.2565	4.52	.0925	.0054	4.3190	1.8292	11.39	4.09	18.54	36
1.2684	.4509	.1510	.2999	5.33	.0575	.0103	4.9126	1.5728	10.75	3.33	14.84	37

at Corresponding Hours.

1.9063	.7429	.2589	.4840	6.15	.0351	.0065	6.2493	2.0071	8.90	3.29	12.61	38
1.3754	.5974	.1711	.4263	6.40	.0247	.0099	7.6446	1.4301	12.02	3.52	12.06	39
1.1669	.3263	.1317	.1946	5.45	.0481	.0114	3.8384	1.8497	13.52	3.48	21.97	40
0.6249	.1371	.0423	.0948	3.30	.1221	.0134	1.9181	1.0041	8.57	3.03	12.73	41
1.2684	.4509	.1510	.2999	5.33	.0575	.0103	4.9126	1.5728	10.75	3.33	14.84	42

Odor of all samples, offensive.——The samples of sewage were collected from the chamber at the outlet of the sewer leading to the precipitation works, just in front of the screen through which the sewage passes before being treated with chemicals. A sample was collected every 6 hours and was made up of 12 equal portions, collected at half-hour intervals. The first collection was made at 8 A.M., July 22, 1891.

BLACKSTONE RIVER.

Chemical Examination of Effluent from

[Parts per 100,000.]

	Number.	Date of Collection. 1891.	Date of Examination. 1891.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total. Total.	Total. Dissolved.	Total. Sus-pended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Loss on Ignition. Sus-pended.
		July.	July.									
1	7591	22, 2 P.M. to 8 P.M.	23	Decided, milky.	Cons., rusty.	0.10	77.80	56.00	21.80	16.60	15.60	1.00
2	7601	22-23, 8 P.M. to 2 A.M.	24	Decided, milky.	Cons., rusty.	0.15	57.80	54.20	3.60	13.00	12.80	.20
3	7603	23, 2 A.M. to 8 A.M.	24	Distinct.	Cons., r'y.	0.10	63.40	60.40	3.00	10.60	10.80	*
4	7604	23, 8 A.M. to 2 P.M.	24	Slight.	Cons., r'y.	0.03	53.60	46.20	7.40	10.50	11.80	*
5	7616	23, 2 P.M. to 8 P.M.	25	Distinct, milky.	Cons., rusty.	0.10	49.40	29.20	20.20	10.00	9.40	.60
6	7620	23-24, 8 P.M. to 2 A.M.	25	Decided.	He'vy, r'y.	0.20	54.40	32.00	22.40	9.80	9.20	.60
7	7623	24, 2 A.M. to 8 A.M.	25	Distinct.	Cons., r'y.	0.05	64.40	59.40	5.00	10.00	8.60	1.40
8	7637	24, 8 A.M. to 2 P.M.	26	Slight, milky.	Cons., rusty.	0.00	44.80	42.60	2.20	10.00	11.80	*
9	7653	24, 2 P.M. to 8 P.M.	26	Decided, milky.	Cons., rusty.	0.20	52.60	48.20	4.40	13.20	7.20	6.00
10	7651	24-25, 8 P.M. to 2 A.M.	26	Decided, milky.	Cons., rusty.	0.15	58.20	53.00	5.20	13.60	9.60	4.00
11	7652	25, 2 A.M. to 8 A.M.	26	Distinct, milky.	Cons., rusty.	0.05	56.80	53.20	3.60	9.60	9.80	*
12	7659	25, 8 A.M. to 2 P.M.	27	Slight.	Slight, r'y.	0.00	37.60	34.60	3.00	8.00	7.60	.40
13	7676	25, 2 P.M. to 8 P.M.	28	Decided.	Cons., r'y.	0.15	46.00	41.00	5.00	14.60	8.40	6.20
14	7674	25-26, 8 P.M. to 2 A.M.	28	Decided.	Cons., r'y.	0.20	55.20	51.20	4.00	12.20	12.40	*
15	7675	26, 2 A.M. to 8 A.M.	28	Distinct.	Slight, r'y.	0.15	66.00	60.40	5.60	16.40	13.80	2.60
16	7677	26, 8 A.M. to 2 P.M.	28	Distinct.	Slight, r'y.	0.10	47.00	44.60	2.40	13.60	11.40	2.20
17	7683	26, 2 P.M. to 8 P.M.	28	Distinct, milky.	Cons., rusty.	0.20	43.40	41.40	2.00	13.60	12.00	1.60
18	7687	26-27, 8 P.M. to 2 A.M.	29	Distinct.	Cons.	0.25	43.40	39.60	3.80	11.80	10.00	1.80
19	7685	27, 2 A.M. to 8 A.M.	29	Distinct.	Cons., r'y.	0.20	38.00	35.00	3.00	10.80	9.00	1.80
20	7690	27, 8 A.M. to 2 P.M.	29	Slight.	Cons., r'y.	0.30	35.20	28.20	7.00	10.80	6.40	4.40
21	7701	27, 2 P.M. to 8 P.M.	29	Decided, milky.	Slight, rusty.	0.20	50.80	47.00	3.80	18.00	17.00	1.00
22	7703	27-28, 8 P.M. to 2 A.M.	29	Decided.	Cons., r'y.	0.20	63.80	51.60	12.20	19.40	8.00	11.40
23	7707	28, 2 A.M. to 8 A.M.	29	Distinct.	Slight, r'y.	0.20	59.80	59.00	.80	16.40	16.20	.20
24	7710	28, 8 A.M. to 2 P.M.	29	Slight.	Slight, r'y.	0.00	48.20	42.40	5.80	13.00	10.20	2.80
25	7711	28, 2 P.M. to 8 P.M.	30	Distinct.	Slight, r'y.	0.40	54.00	51.00	3.00	19.00	18.00	1.00
26	7720	28-29, 8 P.M. to 2 A.M.	30	Decided, milky.	Cons., rusty.	0.20	51.80	49.60	2.20	10.60	17.60	*
27	7722	29, 2 A.M. to 8 A.M.	30	Distinct.	Cons., r'y.	0.05	56.40	52.60	3.80	8.80	12.00	*
28	7727	29, 8 A.M. to 2 P.M.	30	Slight, milky.	Slight, rusty.	0.10	44.40	42.40	2.00	9.00	9.20	*
29	Av.	....	....	....	....	0.14	52.65	46.64	6.01	12.60	11.28	1.32

Averages of the

		Color.	Total.	Dissolved.	Sus-pended.	Loss Total.	Loss Dissolved.	Loss Sus-pended.
30	For the 24 hours beginning at 2 P.M., Wednesday, July 22,	0.09	63.15	54.20	8.95	12.67	12.75	*
31	For the 24 hours beginning at 2 P.M., Thursday, July 23,	0.09	53.25	40.80	12.45	9.95	9.75	.20
32	For the 24 hours beginning at 2 P.M., Friday, July 24, .	0.10	51.30	47.25	4.05	11.10	8.55	2.55
33	For the 24 hours beginning at 2 P.M., Saturday, July 25,	0.15	53.55	49.30	4.25	14.20	11.50	2.70
34	For the 24 hours beginning at 2 P.M., Sunday, July 26, .	0.24	40.00	36.05	3.95	11.75	9.35	2.40
35	For the 24 hours beginning at 2 P.M., Monday, July 27, .	0.15	55.65	50.00	5.65	16.70	12.85	3.85
36	For the 24 hours beginning at 2 P.M., Tuesday, July 28,	0.19	51.65	48.90	2.75	11.85	14.20	*
37	Average, ...	0.14	52.65	46.64	6.01	12.60	11.28	1.32

Averages of Samples collected

		Color.	Total.	Dissolved.	Sus-pended.	Loss Total.	Loss Dissolved.	Loss Sus-pended.
38	For the hours from 2 P.M. to 8 P.M., ...	0.19	53.43	44.83	8.60	15.00	12.51	2.49
39	For the hours from 8 P.M. to 2 A.M., ...	0.19	54.94	47.31	7.63	12.91	11.37	1.54
40	For the hours from 2 A.M. to 8 A.M., ...	0.11	57.83	54.29	3.54	11.80	11.46	.34
41	For the hours from 8 A.M. to 2 P.M., ...	0.08	44.40	40.14	4.26	10.70	9.77	.93
42	Average, ...	0.14	52.65	46.64	6.01	12.60	11.28	1.32

* In these cases the loss on ignition was greater after filtering the effluent through filter paper than before. This was probably due to the difficulty in making these determinations accurately with samples of this character. As the errors are likely to vary as much in one direction as in the other, the average of all determinations as given at the bottom of the table is probably very nearly correct.

BLACKSTONE RIVER.

the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.					Nitrogen as		Oxygen Consumed.					
	Albuminoid.											
Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).	
1.3700	.3200	.2260	.0940	5.65	.0500	.0400	1.4080	1.1910	0.49	12.06	16.02	1
1.3100	.3060	.1960	.1100	6.30	.0700	.0800	1.5910	.8830	0.50	12.72	15.41	2
.9700	.1400	.1300	.0100	5.22	.0650	.0150	1.5660	.6910	0.60	17.20	22.79	3
.6500	.0740	.0560	.0180	3.25	.1100	.0090	.5330	.3660	0.18	13.00	16.96	4
1.4540	.2980	.2160	.0820	4.90	.0100	.1050	.9080	.8410	0.37	12.30	15.16	5
1.2040	.2960	.2280	.0680	6.00	.0050	.0050	1.7240	1.2160	0.54	12.74	15.29	6
.9400	.1500	.1360	.0140	4.80	.1100	.0105	1.1830	.7490	0.39	17.28	23.73	7
.6940	.0780	.0680	.0100	2.80	.0050	.0105	.6210	.6100	0.25	13.74	17.10	8
1.2600	.2420	.2100	.0320	3.80	.0100	.1600	1.3830	1.0330	0.28	12.84	15.15	9
1.1300	.2120	.1660	.0460	4.60	.0070	.1000	1.1740	1.0660	0.59	15.42	17.92	10
.9300	.1120	.0840	.0280	3.75	.0900	.0200	.9220	.7660	0.42	16.48	20.48	11
.5500	.0700	.0660	.0040	2.40	.1250	.0080	.5170	.4440	0.22	10.28	12.38	12
1.2000	.2380	.2140	.0240	4.60	.0150	.0800	1.0790	1.0560	0.40	10.40	13.03	13
1.1100	.2980	.2400	.0580	5.60	.0200	.0600	1.3340	1.2690	0.60	12.86	15.49	14
1.1100	.1640	.1440	.0200	5.80	.0500	.0500	1.0240	.8420	0.16	19.52	21.65	15
1.0800	.1300	.0920	.0420	5.20	.1500	.0400	.4370	.4060	0.22	11.98	12.85	16
1.9800	.2080	.1740	.0340	5.35	.0120	.1050	.9140	.6668	0.07	9.94	10.48	17
2.1900	.2520	.1700	.0820	6.20	.0150	.1050	.9750	.5700	0.50	7.60	8.38	18
1.6300	.1760	.1100	.0660	4.70	.0120	.0800	.6660	.5160	0.23	6.66	6.46	19
1.2000	.1180	.0880	.0300	3.60	.1800	.0160	.3620	.3420	0.41	6.12	7.00	20
1.6600	.2880	.2600	.0280	5.70	.0100	.0800	1.3180	.9830	0.49	9.50	11.45	21
1.1600	.2560	.2220	.0340	6.70	.0070	.0700	1.8380	1.3760	0.89	13.34	15.42	22
1.1600	.1900	.1240	.0660	4.90	.0150	.0800	1.2590	.9860	0.62	16.32	22.50	23
.7800	.0900	.0640	.0260	3.00	.1200	.0070	.7160	.5330	0.35	12.22	16.02	24
1.4000	.3120	.2980	.0140	5.00	.1200	.0070	1.2860	1.1710	0.53	13.02	16.80	25
1.3200	.2980	.2400	.0580	5.40	.0070	.0500	1.4960	.9180	0.50	12.40	15.25	26
1.0100	.1660	.1280	.0380	4.50	.0180	.0900	.8100	.7750	0.63	15.68	20.64	27
.7200	.1020	.0960	.0060	3.80	.1100	.0900	.5920	.4600	0.15	13.12	16.87	28
1.1829	.1994	.1588	.0406	4.77	.0542	.0562	1.0583	.8116	0.41	12.74	15.66	29

above Samples by Days.

Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).	
1.0750	.2100	.1520	.0580	5.10	.0737	.0360	1.2745	.7827	0.44	13.74	17.79	30
1.0730	.2055	.1620	.0435	4.62	.0325	.0327	1.1090	.8540	0.39	14.01	17.82	31
0.9675	.1590	.1315	.0275	3.64	.0580	.0720	0.9990	.8272	0.38	13.75	16.47	32
1.1125	.2075	.1725	.0350	5.30	.0587	.0575	0.9685	.8932	0.34	13.69	15.75	33
1.7500	.1885	.1355	.0530	4.96	.0547	.0765	0.7292	.5237	0.30	7.58	8.08	34
1.1900	.2060	.1675	.0385	5.07	.0380	.0592	1.2815	.9695	0.59	12.84	16.35	35
1.1125	.2195	.1905	.0290	4.67	.0637	.0592	1.0460	.8310	0.45	13.55	17.39	36
1.1829	.1994	.1588	.0406	4.77	.0542	.0562	1.0583	.8116	0.41	12.74	15.66	37

at corresponding Hours.

Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).	
1.4749	.2723	.2283	.0440	5.00	.0324	.0824	1.1844	0.9917	0.38	11.44	14.01	38
1.3463	.2740	.2089	.0651	5.83	.0187	.0671	1.4474	1.0426	0.59	12.44	14.74	39
1.1071	.1569	.1223	.0346	4.81	.0614	.0494	1.0614	0.7607	0.44	15.59	19.74	40
0.8084	.0946	.0757	.0189	3.44	.1143	.0258	0.5397	0.4516	0.25	11.49	14.17	41
1.1829	.1994	.1588	.0406	4.77	.0542	.0562	1.0583	0.8116	0.41	12.74	15.66	42

Odor of all samples, offensive.——The samples were collected at the weir where the effluent flows from the last precipitation tank. A sample was collected every 6 hours, and was made up of 12 equal portions collected at half-hour intervals. The first collection was made at 2 P.M., July 22, 1891.

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Dam of Quinsigamond Iron and Wire Works just above Mill Brook Channel.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.
	1891. July.										
7588	22	23	Decided.	Cons.	0.85	6.80	2.25	.0096	.0604	.0350	.0254
7640	23	26	Distinct.	Cons., rusty.	1.00	6.50	1.90	.0028	.0540	.0212	.0328
7641	24	26	Distinct.	Cons., rusty.	1.00	6.40	2.40	.0060	.0504	.0364	.0140
7672	25	28	Distinct.	Sl'ht, rusty.	1.00	7.10	3.60	.0086	.0418	.0266	.0152
7680	26	28	V. slight.	Sl'ht, rusty.	1.30	7.00	2.80	.0348	.0344	.0304	.0040
7697	27	29	Distinct.	Sl'ht, rusty.	0.90	6.80	1.70	.0390	.0490	.0346	.0144
7716	28	30	Distinct.	Cons.	0.60	8.00	3.40	.0154	.0526	.0386	.0140
Av...	......	......	....	....	0.95	6.94	2.58	.0166	.0489	.0318	.0171

Number.	Date of Collection.	Date of Examination.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
	1891. July.									
7588	22	23	.27	.0120	.0001	.8230	-	-	-	-
7640	23	26	.30	.0150	.0001	.7850	.7680	-	-	-
7641	24	26	.30	.0120	.0003	.9380	.9280	-	-	-
7672	25	28	.25	.0150	.0002	-	-	-	-	-
7680	26	28	.24	.0090	.0000	-	-	-	-	-
7697	27	29	.28	.0100	.0001	-	-	-	-	-
7716	28	30	.29	.0090	.0001	-	-	-	-	-
Av.	......	......	.27	.0117	.0001	*.7030	-	*0.36	*0.77	*0.80

Odor, vegetable and musty, or none.——The samples were collected from the river at the dam. Each sample was made up of 4 equal portions collected at intervals of about 4 hours, beginning at 8 A.M.

* These determinations were made upon a mixture of equal parts of water from all the samples.

BLACKSTONE RIVER.

Microscopical Examination of Water from Blackstone River at Dam of Quinsigamond Iron and Wire Works just above Mill Brook Channel.

[Number of organisms per cubic centimeter.]

	1891.						
	-	July.	July.	July.	July.	July.	July.
Day of examination,	-	27	27	28	28	29	29
Number of sample,	7588	7640	7641	7672	7680	7697	7716
PLANTS.							
Diatomaceæ,	-	8	0	1	16	18	10
Asterionella,	-	0	0	0	0	5	1
Cyclotella,	-	4	0	0	1	0	0
Melosira,	-	0	0	0	0	3	0
Navicula,	-	1	0	1	1	4	2
Synedra,	-	3	0	0	14	6	7
Cyanophyceæ. Chroöcoccus,	-	16	0	0	0	0	0
Algæ,	-	46	1	7	41	13	5
Chlorococcus,	-	38	0	0	35	6	1
Pandorina,	-	1	0	2	2	0	0
Pediastrum,	-	3	0	1	1	0	1
Raphidium,	-	4	1	0	0	0	0
Scenedesmus,	-	0	0	2	3	5	3
Staurastrum,	-	0	0	2	0	2	0
Fungi,	-	136	600	187	140	114	11
Crenothrix,	-	130	600	184	140	112	11
Molds,	-	6	0	3	0	2	0
ANIMALS.							
Infusoria,	-	6	3	5	8	6	0
Ciliated infusorian,	-	0	1	0	0	0	0
Dinobryon,	-	0	0	0	0	1	0
Glenodinium,	-	0	0	0	4	0	0
Monas,	-	3	2	4	1	2	0
Paramæcium,	-	0	0	1	1	0	0
Peridinium,	-	0	0	0	2	1	0
Trachelomonas,	-	3	0	0	0	2	0
Vermes,	-	1	7	4	3	0	0
Polyarthra,	-	1	0	0	0	0	0
Rotatorian ova,	-	0	7	4	3	0	0
Crustacea. Cyclops,	-	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	-	1,160	798	1,498	358	520	968
TOTAL,	-	1,373	1,409	1,700	566	671	994

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River between

[Parts per 100,000.]

	Number.	Date of Collection. 1891.	Date of Examination. 1891.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dissolved.	Total Residue. Sus-pended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Loss on Ignition. Sus-pended.
1	7590	July. 22, 8 A.M. to 2 P.M.	July. 23	Decided, milky.	Heavy, dark.	0.10	30.80	17.40	13.40	8.20	4.20	4.00
2	7594	22, 2 P.M. to 8 P.M.	24	Decided, milky.	Heavy, dark.	0.25	30.80	19.80	11.00	9.00	6.40	2.60
3	7608	22-23, 8 P.M. to 8 A.M.	24	Decided.	Heavy, dark.	0.20	27.20	21.60	5.60	9.60	6.20	3.40
4	7605	23, 8 A.M. to 2 P.M.	24	Distinct.	Heavy, dark.	0.10	37.00	21.20	15.80	11.60	6.00	5.60
5	7615	23, 2 P.M. to 8 P.M.	25	Decided.	Heavy, dark.	0.40	24.80	10.40	14.40	7.80	2.40	5.40
6	7622	23-24, 8 P.M. to 8 A.M.	25	Distinct.	Cons'ble.	0.90	27.80	18.00	9.80	10.00	4.80	5.20
7	7634	24, 8 A.M. to 2 P.M.	26	Decided.	Very heavy.	0.15	35.00	21.60	13.40	7.00	6.40	0.60
8	7645	24, 2 P.M. to 8 P.M.	26	Decided.	Very heavy.	0.40	57.40	15.60	41.80	12.40	8.00	4.40
9	7654	24-25, 8 P.M. to 8 A.M.	26	Decided.	Heavy.	0.10	31.00	24.80	6.20	8.40	7.00	1.40
10	7658	25, 8 A.M. to 2 P.M.	27	Decided.	Very heavy.	0.25	27.00	14.00	13.00	6.80	4.00	2.80
11	7673	25, 2 P.M. to 8 P.M.	28	Distinct.	Heavy, dark.	0.10	31.40	23.40	8.00	11.20	5.40	5.80
12	7664	25-26, 8 P.M. to 8 A.M.	28	Distinct.	Cons'ble.	1.40	18.40	14.00	4.40	6.20	3.60	2.60
13	7665	26, 8 A.M. to 2 P.M.	28	Distinct.	Heavy, rusty.	0.10	16.40	8.60	7.80	5.60	2.80	2.80
14	7684	26, 2 P.M. to 8 P.M.	28	Slight.	Cons'ble.	1.10	18.40	11.60	6.80	8.00	5.80	2.20
15	7693	26-27, 8 P.M. to 8 A.M.	29	Slight.	Cons'ble, rusty.	2.80	14.80	9.00	5.80	5.00	4.20	0.80
16	7689	27, 8 A.M. to 2 P.M.	29	Decided.	Heavy, rusty.	0.15	30.80	17.20	13.60	12.60	5.60	7.00
17	7698	27, 2 P.M. to 8 P.M.	29	Decided.	Cons'ble, rusty.	0.10	37.40	27.60	9.80	13.80	11.00	2.80
18	7706	27-28, 8 P.M. to 8 A.M.	29	Decided.	Cons'ble, rusty.	0.20	19.20	12.20	7.00	6.00	4.60	1.40
19	7712	28, 8 A.M. to 2 P.M.	30	Slight.	Heavy, rusty.	0.15	24.20	13.00	11.20	5.20	3.60	1.60
20	7713	28, 2 P.M. to 8 P.M.	30	Distinct.	Heavy.	0.30	23.20	12.00	11.20	6.20	3.20	3.00
21	7721	28-29, 8 P.M. to 8 A.M.	30	Decided.	Cons'ble.	0.05	21.60	18.00	3.60	5.20	3.80	1.40
22	Av.	....	......	....	....	0.44	27.84	16.71	11.13	8.37	5.19	3.18

Averages of the

		Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
23	For the 24 hours beginning at 8 A.M., Wednesday, July 22,	0.18	29.60	19.60	10.00	8.93	5.60	3.33
24	For the 24 hours beginning at 8 A.M., Thursday, July 23,	0.47	29.87	16.53	13.34	9.80	4.40	5.40
25	For the 24 hours beginning at 8 A.M., Friday, July 24, .	0.22	41.13	20.67	20.46	9.27	7.13	2.14
26	For the 24 hours beginning at 8 A.M., Saturday, July 25,	0.58	25.60	17.13	8.47	8.07	4.33	3.74
27	For the 24 hours beginning at 8 A.M., Sunday, July 26, .	1.33	16.53	9.73	6.80	6.20	4.27	1.93
28	For the 24 hours beginning at 8 A.M., Monday, July 27, .	0.15	29.13	19.00	10.13	10.80	7.07	3.73
29	For the 24 hours beginning at 8 A.M., Tuesday, July 28, .	0.17	23.00	14.33	8.67	5.53	3.53	2.00
30	Average, ...	0.44	27.84	16.71	11.13	8.37	5.19	3.18

Averages of Samples collected

		Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
31	For the hours from 8 A.M. to 2 P.M., ...	0.14	28.74	16.14	12.60	8.14	4.66	3.48
32	For the hours from 2 P.M. to 8 P.M., ...	0.38	31.91	17.20	14.71	9.77	6.03	3.74
33	For the hours from 8 P.M. to 8 A.M., ...	0.81	22.86	16.80	6.06	7.20	4.89	2.31
34	Average, ...	0.44	27.84	16.71	11.13	8.37	5.19	3.18

Odor, of all samples, offensive. — The samples were collected from the river at a temporary bridge built opposite the sludge beds of the Worcester precipitation works, and above the place where the sewage and effluent from these works enter the river.

Three samples were collected each 24 hours. The first was made up of three equal portions collected

BLACKSTONE RIVER.

the Mill Brook Channel and the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Iron Oxide (Fe_2O_3).	Lime (CaO).	Sulphuric Acid (SO_3).	
	Albuminoid.											
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.				
.4100	.1440	.0700	.0740	1.62	.0250	.0050	1.5660	1.2920	5.86	1.64	6.85	1
.4500	.1980	.0440	.1540	1.35	.0200	.0030	1.6240	.4330	3.82	1.38	4.19	2
.3500	.0980	.0520	.0460	1.30	.0200	.0035	2.0490	.1750	5.30	2.60	7.27	3
.4100	.1680	.0720	.0960	1.55	.0150	.0055	1.3820	.2500	5.38	1.46	7.13	4
.2400	.1620	.0400	.1220	1.40	.0090	.0001	1.5080	.2500	2.97	1.40	3.42	5
.2100	.1200	.0260	.0940	1.45	.0070	.0000	1.3910	.3998	4.55	1.30	6.25	6
.4840	.1700	.0560	.1140	1.95	.0100	.0055	1.8890	.4310	6.19	1.90	6.87	7
.2440	.1980	.0300	.1680	1.60	.0100	.0000	2.9560	.5490	7.01	2.40	5.07	8
.2100	.0960	.0260	.0700	1.15	.0200	.0090	.9000	.3990	6.39	1.68	9.78	9
.1600	.1240	.0520	.0720	1.00	.0150	.0000	1.3330	.3660	4.19	1.96	5.12	10
.2000	.1000	.0260	.0740	1.25	.0150	.0040	.7730	.4800	6.37	1.60	9.41	11
.3200	.1180	.0660	.0520	1.75	.0260	.0000	1.2660	.5230	2.00	1.44	2.75	12
.1800	.0660	.0240	.0420	1.00	.0100	.0010	.9330	.3500	2.23	1.10	2.98	13
.1600	.0680	.0360	.0320	3.60	.0090	.0010	.8620	.3490	1.75	1.24	1.92	14
.2600	.0860	.0560	.0300	2.80	.0070	.0010	.9010	.6150	2.03	1.02	0.74	15
.2500	.0760	.0320	.0440	3.00	.0050	.0025	.9060	.2150	4.80	2.06	4.67	16
.2900	.0840	.0320	.0520	1.80	.0120	.0040	.9030	.2580	7.15	1.84	9.40	17
.2100	.0800	.0400	.0400	1.40	.0070	.0020	1.1130	.5980	2.77	1.40	3.02	18
.2000	.0920	.0380	.0540	1.85	.0100	.0020	1.2390	.3550	4.02	1.50	5.25	19
.1900	.1240	.0280	.0960	1.20	.0150	.0020	1.4290	.2760	4.81	1.37	4.22	20
.2400	.0820	.0260	.0560	1.00	.0200	.0040	.9330	.3590	3.90	1.18	6.90	21
.2699	.1168	.0415	.0753	1.67	.0134	.0026	1.3241	.4246	4.45	1.60	5.39	22

above Samples by Days.

.4033	.1467	.0553	.0914	1.42	.0217	.0038	1.7463	.6333	4.99	1.87	6.10	23
.2867	.1500	.0460	.1040	1.47	.0103	.0019	1.4270	.2999	4.30	1.39	5.60	24
.3127	.1547	.0373	.1174	1.57	.0133	.0048	1.8983	.4597	6.53	1.99	7.24	25
.2267	.1140	.0480	.0660	1.33	.0167	.0013	1.1240	.4563	4.19	1.67	5.76	26
.2000	.0733	.0387	.0346	2.47	.0087	.0010	0.8987	.4380	2.00	1.12	1.88	27
.2500	.0800	.0347	.0453	2.07	.0080	.0028	0.9740	.3553	4.91	1.77	5.70	28
.2100	.0993	.0307	.0686	1.35	.0150	.0027	1.2003	.3300	4.24	1.35	5.46	29
.2699	.1168	.0415	.0753	1.67	.0134	.0026	1.3241	.4246	4.45	1.60	5.39	30

at Corresponding Hours during the Week.

.2991	.1200	.0491	.0709	1.71	.0129	.0031	1.3140	.4656	4.67	1.66	5.55	31
.2534	.1334	.0337	.0997	1.74	.0129	.0020	1.4364	.3707	4.84	1.60	5.38	32
.2571	.0971	.0417	.0554	1.55	.0144	.0028	1.2219	.4377	3.85	1.52	5.24	33
.2699	.1168	.0415	.0753	1.67	.0134	.0026	1.3211	.4246	4.45	1.60	5.39	34

at intervals of about two hours, beginning at 9 A.M.; the second, also, of three equal portions collected at intervals of two hours, beginning at 3 P.M.; the third sample was made up of two equal portions collected at 1 A.M. and [illegible] M., excepting No. 7693, which was collected at 5.15 A.M. and 7.45 A.M.

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total.			Loss on Ignition.		
	Number.	Collection. 1891.	Examination. 1891.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
		July.	July.									
1	7592	22, 8 A.M. to 2 P.M.	23	Decided, milky.	Heavy.	0.20	37.40	24.20	13.20	12.20	8.60	3.60
2	7593	22, 2 P.M. to 8 P.M.	23	Decided, milky.	Heavy.	0.20	29.20	16.20	13.00	7.80	3.60	4.20
3	7606	22-23, 8 P.M. to 8 A.M.	24	Decided.	Heavy.	0.15	37.00	31.60	5.40	11.00	6.00	5.00
4	7609	23, 8 A.M. to 2 P.M.	24	Decided.	Heavy, dark.	0.15	37.80	22.60	15.20	12.80	6.40	6.40
5	7618	23, 2 P.M. to 8 P.M.	25	Decided.	Heavy, dark.	0.30	31.00	18.20	12.80	9.60	3.60	6.00
6	7621	23-24, 8 P.M. to 8 A.M.	25	Decided.	Heavy, dark.	0.25	34.00	27.40	6.60	6.80	2.40	4.40
7	7635	24, 8 A.M. to 2 P.M.	26	Decided.	V. heavy.	0.30	37.00	20.80	16.20	11.20	6.60	4.60
8	7644	24, 2 P.M. to 8 P.M.	26	Decided.	V. heavy.	0.30	71.60	20.60	51.00	15.60	4.60	11.00
9	7647	24-25, 8 P.M. to 8 A.M.	26	Decided.	Heavy, dark.	0.15	34.20	21.00	13.20	6.80	6.00	.80
10	7660	25, 8 A.M. to 2 P.M.	27	Decided.	Heavy, dark.	0.70	29.00	19.20	9.80	8.00	2.20	5.80
11	7679	25, 2 P.M. to 8 P.M.	28	Decided.	V. heavy.	0.40	35.00	21.60	13.40	7.80	6.20	1.60
12	7681	25-26, 8 P.M. to 8 A.M	28	Decided.	Heavy, dark.	1.40	29.40	24.20	5.20	5.20	3.30	1.90
13	7678	26, 8 A.M. to 2 P.M.	28	Distinct.	Heavy, dark.	0.20	28.00	22.40	5.60	8.60	5.60	3.00
14	7692	26, 2 P.M. to 8 P.M.	29	Slight.	Cons., rusty.	0.10	28.40	21.00	7.40	8.00	6.20	1.80
15	7671	26-27, 8 P.M. to 8 A.M.	28	Decided.	Cons., dark.	0.30	24.00	20.40	3.60	5.00	4.00	1.00
16	7691	27, 8 A.M. to 2 P.M.	29	Distinct.	Heavy.	0.50	44.40	24.00	20.40	16.00	7.20	8.80
17	7699	27, 2 P.M. to 8 P.M.	29	Decided.	Heavy, rusty.	0.15	42.60	28.80	13.80	13.80	10.40	3.40
18	7704	27-28, 8 P.M. to 8 A.M.	29	Decided.	Cons., rusty.	0.20	38.40	34.60	3.80	11.60	10.20	1.40
19	7709	28, 8 A.M. to 2 P.M.	29	Decided.	V. heavy.	0.30	37.60	22.80	14.80	9.60	8.80	0.80
20	7714	28, 2 P.M. to 8 P.M.	30	Decided.	Heavy, dark.	0.35	32.80	26.40	6.40	7.40	6.60	0.80
21	7719	28-29, 8 P.M. to 8 A.M.	30	Decided.	Cons., dark.	0.40	35.00	29.40	5.60	5.80	4.60	1.20
22	Av..	....	....	....	....	0.33	35.90	23.69	12.21	9.55	5.86	3.69

Averages of the

		Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
23	For the 24 hours beginning at 8 A.M., Wednesday, July 22,	0.18	34.53	24.00	10.53	10.33	6.07	4.26
24	For the 24 hours beginning at 8 A.M., Thursday, July 23,	0.23	34.27	22.73	11.54	9.73	4.13	5.60
25	For the 24 hours beginning at 8 A.M., Friday, July 24, .	0.25	47.60	20.80	26.80	11.20	5.73	5.47
26	For the 24 hours beginning at 8 A.M., Saturday, July 25,	0.80	31.13	21.67	9.46	7.00	3.90	3.10
27	For the 24 hours beginning at 8 A.M., Sunday, July 26, .	0.20	26.80	21.27	5.53	7.20	5.27	1.93
28	For the 24 hours beginning at 8 A.M., Monday, July 27, .	0.28	41.80	29.13	12.67	13.80	9.27	4.53
29	For the 24 hours beginning at 8 A.M., Tuesday, July 28,	0.35	35.14	26.20	8.93	7.60	6.67	.93
30	Average, ...	0.33	35.90	23.69	12.21	9.55	5.86	3.69

Averages of Samples collected

		Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
31	For the hours from 8 A.M. to 2 P.M., ...	0.34	35.89	22.29	13.60	11.20	6.49	4.71
32	For the hours from 2 P.M. to 8 P.M., ...	0.26	38.66	21.83	16.83	10.00	5.89	4.11
33	For the hours from 8 P.M. to 8 A.M., ...	0.41	33.14	26.94	6.20	7.46	5.21	2.25
34	Average, ...	0.33	35.90	23.69	12.21	9.55	5.86	3.69

Odor of all samples, offensive. —— The samples were collected from the river about one thousand feet below the point where the effluent from the precipitation works and sewage from the by-pass

BLACKSTONE RIVER.

below the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide ($Fe_2 O_3$).	Lime (Ca O).	Sulphuric Acid (SO_3).	
.6100	.2700	.1320	.1380	2.33	.0150	.0060	2.0910	.8580	5.97	2.64	8.36	1
.5100	.2060	.0460	.1600	2.55	.0200	.0166	2.2570	.9590	3.47	2.54	5.29	2
.5500	.0920	.0640	.0280	4.02	.0070	.0000	.8990	.3920	3.45	6.36	10.86	3
.5100	.1540	.0420	.1120	1.85	.0250	.0058	1.5490	.1500	4.98	3.02	6.00	4
.5340	.2160	.0860	.1300	2.22	.0050	.0000	1.8830	1.7490	2.85	3.36	5.77	5
.5140	.1160	.0740	.0420	2.65	.0020	.0000	1.6660	.7830	3.24	6.36	11.16	6
.5640	.2140	.0840	.1300	2.00	.0070	.0100	2.3290	.7693	5.68	3.00	7.75	7
.5740	.2760	.0420	.2340	2.05	.0070	.0000	3.5490	.8263	6.72	4.04	7.44	8
.3940	.0780	.0420	.0360	2.20	.0070	.0000	1.0670	.4330	2.88	5.34	8.94	9
.3100	.1220	.0400	.0820	1.15	.0100	.0000	1.5660	.3500	3.89	2.42	6.24	10
.5300	.1800	.0780	.1020	2.05	.0070	.0001	1.3060	.2810	4.37	3.96	8.49	11
.6300	.2680	.1020	.1660	3.00	.0070	.0010	1.1460	.3930	1.46	6.24	7.94	12
.5800	.1180	.0560	.0620	2.30	.0070	.0280	.8790	.3630	1.98	4.36	5.76	13
.9900	.1280	.0640	.0640	3.15	.0300	.0080	.9163	.4550	1.47	4.44	4.92	14
.9900	.1480	.0780	.0700	2.95	.0150	.0160	.8530	.4760	1.10	4.44	3.89	15
1.0700	.4360	.1640	.2720	4.20	.0070	.0000	3.2620	.8170	3.96	2.94	4.81	16
1.0200	.2360	.1140	.1220	3.55	.0070	.0000	4.3980	.9750	3.63	4.46	7.83	17
.7300	.1240	.0820	.0420	1.75	.0050	.0105	1.3390	.7350	1.92	7.84	10.98	18
.4600	.1940	.0580	.1360	1.65	.0200	.0040	1.6430	.5530	4.02	3.34	8.68	19
.4600	.2180	.1080	.1100	2.15	.0250	.0040	1.8530	.6690	3.72	3.96	7.65	20
.5600	.1300	.0820	.0480	2.40	.0070	.0000	.9490	.8860	3.26	5.82	11.17	21
.6233	.1869	.0780	.1089	2.48	.0115	.0052	1.7809	.6606	3.52	4.33	7.62	22

above Samples by Days.

Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide ($Fe_2 O_3$).	Lime (Ca O).	Sulphuric Acid (SO_3).	
.5567	.1893	.0807	.1086	2.97	.0140	.0075	1.7490	.7363	4.30	3.85	8.17	23
.5193	.1620	.0673	.0947	2.24	.0107	.0019	1.6993	.8940	3.69	4.25	7.64	24
.5107	.1893	.0560	.1333	2.08	.0070	.0033	2.3150	.6762	5.09	4.13	8.04	25
.4900	.1900	.0733	.1167	2.07	.0080	.0004	1.3393	.3413	3.24	4.21	7.56	26
.8533	.1313	.0660	.0653	2.80	.0173	.0173	0.8828	.4313	1.52	4.41	4.86	27
.9400	.2653	.1200	.1453	3.17	.0063	.0035	2.9997	.8423	3.17	5.08	7.87	29
.4933	.1807	.0827	.0980	2.07	.0173	.0027	1.4817	.7027	3.67	4.37	9.17	28
.6233	.1869	.0780	.1089	2.48	.0115	.0052	1.7809	.6606	3.52	4.33	7.62	30

at Corresponding Hours during the Week.

Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide ($Fe_2 O_3$).	Lime (Ca O).	Sulphuric Acid (SO_3).	
.5863	.2154	.0823	.1331	2.21	.0130	.0077	1.9027	.5515	4.35	3.10	6.80	31
.6597	.2086	.0769	.1317	2.53	.0144	.0041	2.3089	.8449	3.75	3.82	6.77	32
.6240	.1366	.0749	.0617	2.71	.0071	.0039	1.1313	.5854	2.47	6.06	9.28	33
.6233	.1869	.0780	.1089	2.48	.0115	.0052	1.7809	.6606	3.52	4.33	7.62	34

enter the stream. The samples were collected in the same manner as those above the precipitation works, but about half an hour later in each case.

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River above and below Millbury.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total. Total.	Residue on Evaporation. Total. Dissolved.	Residue on Evaporation. Total. Sus-pended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Residue on Evaporation. Loss on Ignition. Sus-pended.
	1891. July.										
7627	24	26	Decided.	Very heavy.	0.50	29.00	25.00	4.00	6.40	5.20	1.20
7646	25	26	Decided.	Heavy, rusty.	0.15	28.00	21.40	6.60	8.60	5.00	3.60
7625	24	25	Decided.	Cons., rusty.	0.10	21.20	15.40	5.80	3.40	2.80	0.60
7655	25	26	Decided.	Cons., rusty.	0.10	20.00	16.60	3.40	4.20	2.00	2.20

Number.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
7627	.6700	.1140	.0520	.0620	3.50	.0050	.0001	.9910	.6730	3.97	4.50	9.89
7646	.5440	.0980	.0320	.0660	2.20	.0070	.0000	1.1000	.3330	3.77	4.28	8.72
7625	.4900	.0520	.0220	.0300	1.62	.0070	.0001	.5990	.4750	0.96	3.18	6.76
7655	.5120	.0660	.0340	.0320	1.80	.0070	.0002	.5670	.4660	1.03	4.08	7.62

Odor, offensive.——Nos. 7627 and 7646 were collected from the river at the outlet of Morse's millpond in Millbury. Nos. 7625 and 7655 were collected from the river about half a mile below the last dam in Millbury. Each sample was made up of three equal portions, collected at intervals of two or three hours, as follows: No. 7627 at 9.15 and 11 30 A.M., and 2.15 P.M.; No. 7646 at 7.15 and 10.30 A.M., and 2 P.M.; No. 7625 at 10.10 and 11.15 A.M., and 3 P.M.; No. 7655 at 8 and 11.15 A.M. and 2.45 P.M.

BLACKSTONE RIVER.

Chemical Examination of Water from Singletary, Dorothy and Coldspring Brooks at Millbury.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.					
						Total.			Loss on Ignition.		
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
	1891. July.										
7629	24	26	Distinct.	Cons., black.	0.2	-	4.70	-	-	2.20	-
7643	25	26	Dist't, milky.	Slight.	0.3	-	3.80	-	-	1.90	-
7628	24	26	Dist't, milky.	Slight.	0.5	10.80	7.60	3.20	4.40	4.00	0.40
7642	25	26	Slight.	Slight.	0.7	-	3.70	-	-	1.40	-
7630	24	26	Slight.	Slight.	0.2	-	4.00	-	-	2.80	-

Number.	Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Iron Oxide Fe_2O_3.	Lime (Ca O).	Sulphuric Acid (SO_3).
		Albuminoid.										
	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.			
7629	.0006	.0432	.0256	.0176	.18	.0050	.0001	.6960	.6410	0.00*	0.68*	0.34*
7643	.0026	.0418	.0290	.0128	.18	.0090	.0001	.7150	.6160			
7628	.1100	.0200	.0140	.0060	.80	.0120	.0001	.8580	.6750	0.17*	1.44*	1.74*
7642	.0166	.0250	.0224	.0026	.19	.0120	.0000	.5850	.5500			
7630	.0108	.0254	.0160	.0094	.15	.0120	.0002	.5500	.3750	-	-	-

Odor of No. 7629, disagreeable; of No. 7643, faintly mouldy, disappearing on heating; of No. 7628, none; of No. 7642, distinctly mouldy, becoming faint on heating; of No. 7630, faintly vegetable.——The first two samples were collected from Singletary Brook, about 100 feet above its mouth; the next two from Dorothy Brook, above the highway bridge near its mouth; and the last one from Coldspring Brook, at the highway bridge, not far from its mouth, at 10.25 A.M. Each sample, except the last, was made up of three equal portions collected at intervals of two or three hours, as follows: No. 7629 at 9.45 and 11.45 A.M., 2.30 P.M.; No. 7643 at 7.30 and 10.45 A.M., 2.15 P.M.; No. 7628 at 10 A.M., 12 M. and 2.45 P.M.; No. 7642 at 7.45 and 11 A.M. and 2.30 P.M.

* These determinations were made after mixing equal parts of each sample.

BLACKSTONE RIVER.

Chemical Examination of Water from the Quinsigamond River at Farnumsville.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.
	1891. July.										
7613	23	25	Distinct.	Slight.	0.25	3.60	1.70	.0000	.0220	.0176	.0044
7638	24	26	Distinct.	Slight, bl'k.	0.30	3.00	0.80	.0026	.0248	.0194	.0054

Number.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide. (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
7613	.18	.0030	.0000	.3460	-	-	-	-
7638	.20	.0120	.0001	.3610	-	0.07	0.67	0.30

Odor, mouldy.——The samples were collected from the Quinsigamond River near the mouth of the stream, just above still water in the millpond, at its confluence with the Blackstone. Each sample was made up of four equal portions collected at intervals during the day as follows: No. 7613 at 10.35 A.M., 1.00, 4.15 and 7.00 P.M.; No. 7638 at 8.25 A.M., 12.15, 4.25 and 7.40 P.M.

Chemical Examination of Water from the Blackstone River at Farnumsville.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.
	1891. July.										
7614	23	25	Decided.	Cons., rusty.	0.1	9.10	2.90	.3120	.0250	.0160	.0090
7639	24	26	Distinct.	Cons., rusty.	0.1	8.90	2.10	.7700	.0400	.0300	.0100

Number.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
7614	.88	.0200	.0002	.3160	.3050	0.37	1.74	3.19
7639	1.00	.0150	.0003	.3950	.3320	0.09	1.88	2.82

Odor, faintly mouldy or musty.——The samples were collected in the tail-race to the first mill, below the confluence of the Blackstone and Quinsigamond rivers. All the water of the river was being drawn through the mill race. Each sample was made up of four equal portions collected at intervals through the day, as follows: No. 7614 at 11.05 A.M., 1.10, 4.30 and 7.15 P.M.; No. 7639 at 8.15 A.M., 12 M., 4.10 and 7.50 P.M.

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River at Uxbridge.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.			
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.		
									Total.	Dissolved.	Suspended.
	1891. July.										
7597	22	24	Distinct.	Slight.	0.20	10.40	2.40	.2350	.0485	.0360	.0125
7611	23	24	Slight.	Slight.	0.15	10.80	2.50	.2850	.0370	.0305	.0065
7632	24	26	Slight.	Slight.	0.30	9.20	1.80	.2250	.0180	.0180	.0000
661	25	27	Distinct.	Slight.	0.20	11.50	1.80	.2550	.0310	.0280	.0030
7663	26	27	Slight.	Slight.	0.40	12.00	2.50	.2230	.0350	.0210	.0140
695	27	29	Slight.	Slight.	0.15	11.20	2.10	.2320	.0320	.0240	.0080
7717	28	30	Distinct.	Slight, rusty.	0.25	12.40	5.00	.2990	.0400	.0320	.0080
Av ...	......	.....	....	....	0.24	11.07	2.59	.2506	.0345	.0271	.0074

Number.	Chlorine.	Nitrogen as		Oxygen Consumed.		Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
		Nitrates.	Nitrites.	Unfiltered.	Filtered.			
7597	.85	.0450	.0001	.3640	-	-	-	-
7611	.89	.0450	.0002	.2670	-	-	-	-
7632	.88	.0450	.0010	.4850	.3080	-	-	-
7661	.86	.0400	.0010	.1360	-	-	-	-
7663	.89	.0500	.0005	.2190	-	-	-	-
7695	.88	.0450	.0001	-	-	-	-	-
7717	.82	.0400	.0002	-	-	-	-	-
Av..	.87	.0443	.0004	*.1330	*.1170	*0.17	*1.99	*3.43

Odor, very faintly vegetable or none. —— The samples from the Blackstone River were collected from the lower end of the canal leading from the upper dam of the Calumet Woolen Company. Each sample was made up of two equal portions, one being collected in the morning and one in the afternoon, as follows: Nos. 7597 and 7663 at 10 A.M. and 3 P.M.; Nos. 7611 and 7632 at 8 A.M. and 3 P.M.; No. 7661 at 7.30 A.M. and 2.30 P.M.; No. 7695 at 10 A.M. and 2.30 P.M.; No. 7717 at 9 A.M. and 3 P.M.

* These determinations were made upon a mixture of equal parts of water from the seven samples

BLACKSTONE RIVER.

Microscopical Examination of Water from the Blackstone River at Uxbridge.

[Number of organisms per cubic centimeter.]

	1891.						
	July.	July.	July.	July.	July.	July.	July.
Day of examination,	23	24	25	28	28	28	29
Number of sample,	7597	7611	7632	7661	7663	7695	7717
PLANTS.							
Diatomaceæ,	19	36	13	14	52	70	33
Diatoma,	pr.	1	4	3	15	20	0
Fragilaria,	4	33	2	0	0	0	4
Melosira,	7	0	0	0	0	0	3
Navicula,	0	0	1	0	1	1	2
Synedra,	8	2	5	11	36	48	16
Tabellaria,	0	pr.	1	0	0	1	8
Cyanophyceæ. Chroöcoccus,	0	0	0	0	8	0	0
Algæ,	14	8	6	9	57	18	38
Chlorococcus,	11	4	0	0	6	5	36
Closterium,	pr.	0	0	2	1	1	0
Pandorina,	2	1	1	1	0	0	0
Pediastrum,	1	pr.	1	1	2	2	0
Scenedesmus,	pr.	2	4	4	7	5	1
Sorastrum,	0	0	0	0	6	3	0
Sphærozosma,	0	0	0	0	34	0	0
Staurastrum,	0	1	pr.	1	1	2	1
Fungi. Crenothrix,	1	0	2	38	50	1	0
ANIMALS.							
Rhizopoda. Actinophrys,	0	0	0	0	0	0	1
Infusoria,	396	372	1,016	153	604	744	250
Ciliated Infusorian,	0	0	0	0	0	0	2
Cryptomonas,	0	0	2	0	0	0	0
Dinobryon,	97	250	862	134	448	472	236
Dinobryon cases,	288	108	146	0	136	252	0
Euglena,	0	0	0	0	0	6	0
Glenodinium,	2	4	0	2	0	0	3
Monas,	0	3	4	3	9	5	0
Peridinium,	6	6	pr.	10	0	3	6
Phacus,	0	0	pr.	0	3	0	0
Trachelomonas,	3	1	2	4	8	6	3
Vermes,	1	pr.	4	1	0	1	0
Anguillula,	0	0	0	1	0	0	0
Anurea,	0	pr.	3	0	0	0	0
Rotatorian ova,	1	0	0	0	0	0	0
Sacculus,	0	0	1	0	0	1	0
Crustacea. Cyclops,	pr.	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	506	206	494	354	708	588	152
TOTAL,	937	622	1,535	569	1,479	1,422	474

BLACKSTONE RIVER.

Chemical Examination of Water from the Mumford River at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.
	1891. July.										
7598	22	24	Slight.	Slight.	0.35	2.85	1.40	.0006.	.0188	.0144	.0044
7631	24	26	Very slight.	Slight.	0.30	3.30	2.20	.0000	.0150	.0144	.0006

Number.	Date of Collection.	Date of Examination.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
	1891. July.									
7598	22	24	.19	.0100	.0000	.2930	-	0.12	0.41	0.62
7631	24	26	.18	.0120	.0003	.2560	-	-	-	-

Odor, musty.——The samples were collected from the Mumford River at a point near the iron bridge on the new road to the freight depot, just below Capron's mill and about three-eighths of a mile above the confluence of the Mumford and Blackstone rivers. The samples were collected at about 4.30 P.M.

Chemical Examination of Water from the West River at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total. Total.	Residue on Evaporation. Total. Dissolved.	Residue on Evaporation. Total. Sus-pended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Residue on Evaporation. Loss on Ignition. Sus-pended.
	1891. July.										
7596	22	24	Slight.	Slight.	0.5	-	4.35	-	-	2.15	-
7626	24	26	Distinct.	Slight.	1.0	5.30	4.10	1.20	2.50	1.90	0.60

Number.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (Ca O).	Sulphuric Acid (SO_3).
7596	.0020	.0322	.0262	.0060	.20	.0120	.0005	.4690	-	0.22	0.52	0.16
7626	.0010	.0260	.0232	.0028	.17	.0200	.0001	.5520	-	0.10	0.49	0.20

Odor, vegetable.——The samples were collected from the West River below the last bridge on the stream, which is a little less than half a mile above its mouth. No. 7596 was collected at 3.30 P.M.; No. 7626 at 2 P.M.

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total. Total.	Residue on Evaporation. Total. Dissolved.	Residue on Evaporation. Total. Sus-pended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Residue on Evaporation. Loss on Ignition. Sus-pended.
	1891. July.										
7599	22	24	Distinct.	Slight.	0.25	-	7.50	-	-	2.40	-
7610	23	24	Slight.	Slight.	0.25	-	7.30	-	-	2.40	-
7633	24	26	Slight.	Slight.	0.15	-	6.40	-	-	2.30	-
7656	25	27	Distinct.	Slight.	0.20	6.70	6.00	0.70	1.90	1.80	0.10
7694	26	29	Slight.	Slight.	0.40	-	8.60	-	-	3.20	-
7696	27	29	Slight.	Slight.	0.25	-	6.30	-	-	1.20	-
7724	28	30	Slight.	Slight.	0.35	-	9.60	-	-	4.00	-
Av....	......	......	....	....	0.26	-	7.39	-	-	2.47	-

Number.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.	Iron Oxide (Fe_2O_3).	Lime (CaO).	Sulphuric Acid (SO_3).
7599	.0650	.0280	.0220	.0060	-	.0300	.0002	.3300	-	-	-	-
7610	.0850	.0280	.0155	.0125	.51	.0480	.0002	.2930	-	-	-	-
7633	.0990	.0135	.0105	.0030	.60	.0550	.0005	.3330	.2965	-	-	-
7656	.0900	.0210	.0170	.0040	.49	.0400	.0002	.0580	-	-	-	-
7694	.0790	.0250	.0230	.0020	.48	.0250	.0003	-	-	-	-	-
7696	.0840	.0170	.0100	.0070	.47	.0250	.0001	-	-	-	-	-
7724	.1090	.0170	.0160	.0010	.54	.0280	.0001	-	-	-	-	-
Av.	.0873	.0214	.0163	.0051	.52	.0359	.0002	*.4270	*.2730	*0.12	*1.12	*1.75

Odor of the first four samples, vegetable or musty; of the last three, none.——The samples were collected from the river just above the bridge, in the village of Millville. Each sample was made up of two equal portions, one being collected at about 8.30 A.M. and one at about 4 P.M.

* These determinations were made upon a mixture of equal parts of water from all the samples.

BLACKSTONE RIVER.

Microscopical Examination of Water from the Blackstone River at Millville, Blackstone.

[Number of organisms per cubic centimeter.]

	1891.						
	July.	July.	July.	July.	July.	July.	July.
Day of examination,	24	24	25	27	28	29	30
Number of sample,	7599	7610	7633	7656	7694	7696	7724
PLANTS.							
Diatomaceæ,	**38**	**24**	**44**	**32**	**22**	**32**	**39**
Asterionella,	0	0	0	0	8	0	0
Diatoma,	0	0	6	3	6	0	9
Fragilaria,	9	0	0	10	0	6	16
Melosira,	1	1	0	0	0	0	1
Navicula,	0	pr.	1	0	2	0	1
Synedra,	27	22	36	15	6	25	10
Tabellaria,	1	1	1	4	0	1	2
Cyanophyceæ,	**7**	**19**	**5**	**20**	**34**	**0**	**0**
Chroöcoccus,	7	19	5	4	34	0	0
Clathrocystis,	0	0	0	16	0	0	0
Algæ,	**30**	**52**	**13**	**4**	**14**	**24**	**9**
Chlorococcus,	26	40	3	1	6	20	5
Pandorina,	pr.	5	1	1	0	1	1
Pediastrum,	0	1	2	0	0	2	0
Raphidium,	0	0	1	0	3	0	1
Scenedesmus,	3	3	3	2	3	1	2
Sorastrum,	0	0	3	0	2	0	0
Staurastrum,	1	3	pr.	0	0	pr.	0
Fungi,	**244**	**98**	**44**	**87**	**132**	**15**	**112**
Beggiatoa,	2	4	4	0	4	0	0
Crenothrix,	242	94	40	87	128	15	112
ANIMALS.							
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Infusoria,	**223**	**395**	**382**	**221**	**474**	**147**	**317**
Dinobryon,	9	323	238	204	314	146	214
Dinobryon cases,	179	0	138	0	152	0	98
Euglena,	0	0	pr.	0	2	0	0
Glenodinium,	1	1	0	0	0	pr.	0
Monas,	0	2	3	5	0	pr.	0
Peridinium,	34	68	2	5	2	1	3
Trachelomonas,	pr.	1	1	7	4	pr.	2
Vermes,	**pr.**	**pr.**	**pr.**	**0**	**0**	**0**	**pr.**
Polyarthra,	pr.	pr.	0	0	0	0	0
Rotatorian ova,	0	pr.	pr.	0	0	0	pr.
Crustacea. Cyclops,	**0**	**pr.**	**pr.**	**0**	**0**	**0**	**pr.**
Miscellaneous. Zoöglœa,	**472**	**130**	**352**	**160**	**258**	**190**	**162**
TOTAL,	1,014	718	840	524	935	408	639

CHICOPEE RIVER.

No examinations of the water of the main river were made during the year; but its principal affluent, the Quaboag River, and its tributaries, were examined in the summer to determine the extent to which they were affected by the sewage and other polluting matters discharged into them.

Chemical Examination of Water from the Quaboag River and Tributaries.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved	Ammonia. Albuminoid. Suspended	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
7508	June 30	July 1	Decided.	Heavy.	0.70	5.10	2.05	.0296	.0950	.0446	.0504	.74	.0180	.0025	2.9
7509	June 30	July 1	Decided.	Cons.	0.70	2.95	0.95	.0174	.0326	.0200	.0126	.16	.0100	.0012	1.3
7517	July 1	July 2	Slight.	Cons.	0.40	3.50	1.05	.0000	.0188	.0166	.0022	.14	.0020	.0002	0.9
7518	July 1	July 2	Slight.	Cons.	0.35	3.10	1.00	.0000	.0160	.0134	.0026	.13	.0020	.0001	0.8
7516	July 1	July 2	Slight.	Cons.	0.20	4.90	1.35	.0060	.0216	.0152	.0064	.14	.0150	.0002	1.1
7515	July 2	July 2	V. slight.	Cons.	0.40	3.85	1.00	.0014	.0184	.0138	.0046	.14	.0100	.0002	1.1

Odor of No. 7508, very disagreeable; of No. 7509, offensive; of No. 7516, distinctly vegetable, becoming mouldy on heating; of the remaining samples, very faintly vegetable. —— The samples were collected as follows: No. 7508 from the brook which flows from Moose Pond through the middle of the town of Spencer to the Seven Mile River, at the point where the brook crosses South Main Street below the village; No 7509, from the Seven Mile River at the road bridge, about half a mile below the outlet of the main sewer of Spencer; No. 7518, from the Quaboag River at the bridge just above Warren; No. 7517, from the Quaboag River at the bridge below West Warren; No. 7516, from the brook which flows northerly through Monson into the Quaboag River a short distance above Palmer. The sample was collected from the brook near its mouth. No. 7515, from the Quaboag River at the road bridge about one mile below Palmer.

CHICOPEE RIVER.

Microscopical Examination of Water from the Quaboag River and Tributaries.

[Number of organisms per cubic centimeter.]

	1891.					
	July.	July.	July.	July.	July.	July.
Day of examination,	1	1	2	2	2	2
Number of sample,	7508	7509	7517	7518	7516	7515
PLANTS.						
Diatomaceæ,	47	11	27	11	39	40
Cocconeis,	0	0	2	0	pr.	5
Diatoma,	0	0	0	3	0	4
Melosira,	0	0	8	3	3	0
Navicula,	0	pr.	5	4	5	31
Nitzschia,	0	0	0	1	7	0
Synedra,	47	pr.	11	0	pr.	0
Tabellaria,	0	11	1	0	24	pr.
Cyanophyceæ,	244	1	85	110	0	9
Anabæna,	0	0	8	0	0	0
Chroöcoccus,	232	0	0	15	0	0
Cœlosphærium,	0	0	29	1	0	1
Microcystis,	0	0	48	54	0	8
Nostoc,	0	0	0	40	0	0
Oscillaria,	12	1	0	0	0	0
Algæ,	4,262	19	10	52	2	30
Botrycoccus,	0	0	0	0	0	4
Chlorococcus,	75	1	pr.	29	pr.	21
Closterium,	4,150	18	0	pr.	0	0
Conferva,	0	0	0	9	0	0
Hyalotheca,	0	0	0	7	0	0
Raphidium,	0	0	0	7	0	0
Scenedesmus,	32	pr.	1	0	2	5
Sphærozosma,	0	0	7	0	0	0
Spirogyra,	5	0	2	0	0	0
Fungi. Crenothrix,	285	32	4	2	32	6
ANIMALS.						
Rhizopoda. Actinophrys,	0	0	4	6	0	0
Infusoria,	54	2	3	pr.	228	10
Dinobryon,	0	0	0	0	226	10
Glenodinium,	27	pr.	1	0	1	pr.
Monas,	0	0	0	pr.	pr.	0
Trachelomonas,	27	2	2	pr.	1	pr.
Vermes. Rotatorian ova,	0	pr.	1	0	1	pr.
Crustacea. Cyclops,	pr.	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	945	100	88	360	176	218
TOTAL,	5,837	165	222	541	478	313

MERRIMACK RIVER.

Regular monthly examinations of the water of the Merrimack River have been made during the year at points opposite the intakes of the Lawrence and Lowell water works, the detailed results of

MERRIMACK RIVER.

which will be found on pages 142 and 151 of this volume. A comparison of the analyses at these two places is contained in the following table: —

Comparison of Analyses, above Lowell and above Lawrence, 1891.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Number of determinations compared,	11	11	11	11	11	11	11	11	11	11	10
Mean of analyses above Lowell,	0.29	3.50	1.25	.0019	.0129	.0100	.0029	.140	.0140	.0001	1.2
Mean of analyses above Lawrence,	0.27	3.79	1.32	.0040	.0152	.0121	.0031	.175	.0110	.0001	1.3
Increase,	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1

* Decrease.

In order to compare these results with similar ones obtained in previous years, another table is presented which contains the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table and the corresponding increase in previous years.

Increase in the amount of impurities in the Merrimack River Water from a point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of different years.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Increase, 1887-1889,	0.01	0.23	0.09	.0007	.0027	.0017	.0009	.026	.0003*	.0000	-
Increase, 1890,	0.05	0.62	0.22*	.0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891,	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1

The average flow of the river at Lawrence, per 24 hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948 and 7,931 cubic feet per second.

* Decrease.

MERRIMACK RIVER.

A third table is given below, which corresponds with the one last given, except that it is based upon the results of special examinations made during low stages of the river instead of upon the regular monthly examinations for the whole year; and consequently shows to a greater degree the effect of discharging the sewage and manufacturing wastes of Lowell into the river.

Increase in the amount of impurities in the Merrimack River Water from a point above Lowell to Lawrence, as determined by special examinations during low stages of the River.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
Increase, Aug. 16, 17, 1888,	0.05	0.02*	0.07	.0021	.0048	.0018	.0030	.02	.0034	.0000	-
Increase, Oct. 12, 13; Nov. 4, 5, 1891, ...	0.02	0.48	0.03	.0061	.0074	.0053	.0021	.07	.0007	.0000	0.4

The average flow of the river at Lawrence, per 24 hours, during the days on which samples were collected, was, in 1888, at the rate of 4,000 cubic feet per second, and in 1891, 2,285 cubic feet per second.

* Decrease.

While the examinations of recent years have almost always shown a decided deterioration in the quality of the water caused by the polluting matters discharged into the river at Lowell, this effect has never been more noticeable than during the past year and particularly during the drier portion of the year. This may be ascribed both to the unusually low flow of the river during a portion of the year and to the constantly increasing amount of polluting matter discharged into it.

Still another table is presented below which includes a greater length of river than any of the foregoing tables and gives in a condensed form the results of two special examinations of the river during the dry portion of 1891. The analyses on which this table is based are given in detail on pages 302–304.

MERRIMACK RIVER.

Special Examination of the Merrimack River on Oct. 12, 13, and Nov. 4, 5, 1891.

[Parts per 100,000.]

	Number of Samples.	Color.	Residue on Evaporation.				Ammonia.				Chlorine.	Nitrogen as		Hardness.
			Total.		Loss on Ignition.			Albuminoid.						
			Unfilt'd.	Filtered	Unfilt'd.	Filtered.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	
Above Lowell, .	4	0.24	-	3.91	-	1.16	.0031	.0144	.0119	.0025	.23	.0097	.0001	1.3
Below Lowell, .	5	0.23	-	4.51	-	1.16	.0042	.0221	.0161	.0055	.26	.0090	.0002	1.4
Above Lawrence,	5	0.26	-	4.40	-	1.21	.0092	.0218	.0172	.0046	.30	.0104	.0001	1.7
Below Lawrence,	6	0.25	5.23	4.77	1.65	1.41	.0031	.0249	.0170	.0079	.31	.0085	.0003	1.5
Above Haverhill,	4	0.30	-	5.91	-	2.04	.0043	.0309	.0213	.0096	.39	.0095	.0002	1.7
Below Haverhill,	4	0.26	-	5.55	-	1.77	.0031	.0271	.0201	.0070	.36	.0097	.0002	1.7

The average flow of the river at Lawrence, per 24 hours, during these examinations was at the rate of 2,285 cubic feet per second.

This table corresponds to one published on page 799 of the special report of the Board upon the Examination of Water Supplies, 1890, but shows a much greater pollution of the river water; for instance, by comparing the two years and indicating only the increase in the more important constituents, from a point above Lowell to one above Haverhill, we have the following results: —

Increase from above Lowell to above Haverhill.

DATE.	Total Residue.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
Increase, Aug. 16, 17, 1888, ...	0.50	.0000	.0057	.03
Increase, Oct. 12, 13, Nov. 4, 5, 1891, . .	2.00	.0012	.0165	.16

The number of bacteria per cubic centimeter found in the river water during the examinations of 1891 was as follows: —

	October 13.	November 4-5.
Above Lowell, ...	-	1,930
Below Lowell, ...	-	3,700
Above Lawrence, ...	12,400	2,550
Below Lawrence, ...	13,800	2,700
Above Haverhill, ...	-	3,250
Below Haverhill, ...	-	4,200

It will be seen that there is a great difference in the number of bacteria found in the river water at different times, also that there is a general progressive increase in the number as the sewage of the several cities is added to the stream.

Another special examination of the river was made in January and February, 1891, in connection with epidemics of typhoid fever at Lowell and Lawrence. At this time the river was covered with ice, the volume flowing was large and the water was in good condition from a chemical stand-point. Bacteriological examinations were made, which included samples taken on five days at various points on the river, and the numbers found ranged from 920 to 10,800 per cubic centimeter. The smallest numbers were found above Nashua, but from below Nashua to Lawrence the variation in numbers did not appear to follow any regular law. Two series of examinations of the water at various points between Lowell and Lawrence, which were made to determine whether any purification could be detected, either chemically or bacteriologically, as the water passed from point to point, are given in the table below. It will be seen that there was no marked improvement in the quality of the water from either stand-point.

Chemical and Bacteriological Examination of Water from the Merrimack River at several points between Lowell and Lawrence.

[Parts per 100,000.]

Number.	Date of		Appearance.			Ammonia.		Chlorine.	Nitrogen as		Oxygen consumed.	Bacteria per cubic centimeter.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
	1891.											
5854	Jan. 7	Jan. 7	Slight.	Slight.	.27	.0070	.0206	.23	.0100	.0003	.39	1,880
5853	Jan. 7	Jan. 7	Slight.	Slight.	.24	.0044	.0148	.18	.0100	.0001	.87	3,010
5852	Jan. 7	Jan. 7	V. slight.	Slight.	.25	.0032	.0134	.19	.0100	.0001	.37	1,500
5850	Jan. 7	Jan. 7	V. slight.	Slight.	.27	.0058	.0144	.21	.0100	.0001	.87	1,080
5908	Jan. 14	Jan. 14	Slight.	Slight.	.27	.0054	.0138	.18	.0200	.0000	.34	4,070
5909	Jan. 14	Jan. 14	Slight.	Slight.	.25	.0054	.0152	.18	.0190	.0000	.35	2,680
5910	Jan. 14	Jan. 14	Slight.	Slight.	.26	.0050	.0142	.18	.0200	.0000	.35	4,600
5911	Jan. 14	Jan. 14	Slight.	Slight.	.26	.0040	.0132	.18	.0190	.0000	.36	2,440
5912	Jan. 14	Jan. 14	Slight.	Slight.	.26	.0044	.0130	.18	.0170	.0000	.35	3,180

The samples were collected as follows: No. 5908 just below Hunt's Falls at Lowell; Nos. 5854 and 5909 a short distance below the mouth of Trull Brook and about 5½ miles above the pumping station of the Lawrence Water Works; Nos. 5853 and 5910 about half a mile above the mouth of Fish brook and 3½ miles above the pumping station; Nos. 5852 and 5911 opposite the mouth of Bartlett's Brook, two miles above the pumping station; Nos. 5850 and 5912 opposite the pumping station at Lawrence. The river was frozen over from below Hunt's Falls to the pumping station at Lawrence.

MERRIMACK RIVER.

Chemical Examination of Water from the Merrimack River, above Lowell, at the Intake of the Lowell Water Works.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
8071	Oct. 12	Oct. 14	Slight.	Slight.	0.20	4.20	1.05	.0024	.0140	.0112	.0028	.27	.0090	.0001	1.4
8076	Oct. 12	Oct. 14	V. slight.	V. slight.	0.20	3.65	1.20	.0028	.0140	.0122	.0018	.22	.0090	.0000	1.4
8216	Nov. 4	Nov. 5	V. slight.	Slight.	0.28	*4.15 3.70	*1.65 1.20	.0026	.0146	.0118	.0028	.22	.0120	.0002	1.3
8217	Nov. 4	Nov. 5	V. slight.	V. slight	0.28	*4.15 4.10	*1.40 1.20	.0046	.0150	.0124	.0026	.22	.0090	.0002	1.3
Av..	....	....	....	....	0.24	3.91	1.16	.0031	.0144	.0119	.0025	.23	.0097	.0001	1.3

Odor of No. 8071 faintly mouldy; of the others vegetable.——The samples were collected opposite the intake of the water works; Nos. 8071 and 8216 were collected from the north half of the river and Nos. 8076 and 8217 from the south half.

* These determinations were made upon the water before it had been filtered through filter paper.

Chemical Examination of Water from the Merrimack River below Lowell.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
8072	Oct. 12	Oct. 14	Slight.	Slight, gray.	0.15	4.15	1.20	.0018	.0230	.0180	.0050	.26	.0070	.0001	1.6
8077	Oct. 12	Oct. 14	Slight.	Slight, gray.	0.20	5.05	1.20	.0012	.0188	.0140	.0048	.29	.0100	.0001	1.6
8218	Nov. 4	Nov. 5	Slight.	Cons.	0.28	*4.25 4.10	*1.20 1.20	.0050	.0192	.0138	.0054	.15	.0090	.0002	1.1
8219	Nov. 4	Nov. 5	Slight.	Cons.	0.28	*4.60 4.30	*1.25 1.10	.0062	.0224	.0152	.0072	.27	.0100	.0002	1.3
8022	Nov. 4	Nov. 5	Distinct.	Slight.	0.30	*5.55 4.90	*1.15 1.05	.0096	.0256	.0200	.0056	.33	.0090	.0002	1.4
Av.	....	....	....	....	0.23	4.50	1.15	.0042	.0221	.0161	.0055	.26	.0090	.0002	1.4

Odor, vegetable, and generally mouldy.——The samples were collected below Lowell and below Hunt's falls at the place where samples were collected in 1888. No. 8072 was collected from the northerly portion of the stream and No. 8077 from the middle portion. The last three samples, Nos. 8218, 8219 and 8220 were collected, respectively, from the northerly, middle and southerly thirds of the stream.

* These determinations were made upon the water before it had been filtered through filter paper.

MERRIMACK RIVER.

Chemical Examination of Water from the Merrimack River at the Intake of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8074	Oct. 13	Oct. 14	Slight.	Slight, gray.	0.30	4.15	0.95	.0110	.0202	.0172	.0030	.30	.0120	.0000	1.7
8075	Oct. 13	Oct. 14	Slight.	Slight.	0.30	4.60	1.45	.0094	.0190	.0164	0026	.28	.0120	.0000	1.7
8073	Oct. 13	Oct. 14	Slight.	Slight.	0.15	4.25	0.95	.0120	.0228	.0190	.0038	.30	.0090	.0000	1.7
8228	Nov. 5	Nov. 6	Slight.	Slight.	0.25	*4.65 4.50	*1.35 1.35	.0078	.0238	.0184	.0054	.32	.0090	.0003	1.7
8229	Nov. 5	Nov. 6	Slight.	Slight, white.	0.28	*4.60 4.45	*1.30 1.25	.0060	.0232	.0148	.0084	.32	.0100	.0004	1.6
Av..	....	....	....	....	0.26	4.39	1.19	.0092	.0218	.0172	.0046	.30	.0104	.0001	1.7

Odor, faintly mouldy or musty. —— The samples were collected from the river opposite the intake of the Lawrence Water Works. The first three samples, Nos. 8074, 8075 and 8073, were collected, respectively, from the northerly, middle and southerly thirds of the stream. Of the last two samples, No. 8228 was collected from the northerly half of the stream and No. 8229 from the southerly half.

* These determinations were made on the water before it had been filtered through filter paper.

Chemical Examination of Water from the Merrimack River below Lawrence.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8112	Oct. 13	Oct. 15	Slight.	Cons., gray.	0.20	*4.90 4.60	1.60* 1.40	.0048	.0246	.0146	.0100	.29	.0070	.0001	1.4
8110	Oct. 13	Oct. 15	Slight.	Cons., gray.	0.25	5.20 4.90	1.60 1.40	.0044	.0234	.0170	.0064	.30	.0070	.0003	1.4
8111	Oct. 13	Oct. 15	Slight, milky.	Cons., gray.	0.25	5.70 5.40	1.90 1.70	.0006	.0212	.0152	.0060	.30	.0050	.0001	1.4
8230	Nov. 5	Nov. 6	Distinct.	Slight.	0.28	5.10 4.30	1.60 1.25	.0044	.0254	.0176	.0078	.31	.0100	.0004	1.6
8231	Nov. 5	Nov. 6	Distinct.	Slight, white.	0.25	5.10 4.75	1.55 1.45	.0036	.0276	.0190	.0086	.32	.0120	.0004	1.6
8232	Nov. 5	Nov. 6	Distinct.	Cons., gray.	0.30	5.40 4.70	1.65 1.25	.0010	.0274	.0188	.0086	.36	.0100	.0004	1.6
Av.	....	....	....	....	0.25	5.23 4.77	1.65 1.41	.0031	.0249	.0170	.0079	.31	.0085	.0003	1.5

Odor, faintly mouldy or musty. —— The samples were collected from the river below Lawrence and just above the mouth of the Shawsheen River. Nos. 8112 and 8230 were collected from the northerly third of the river; Nos. 8110 and 8231 from the middle third, and Nos. 8111 and 8232 from the southerly third.

* The upper line of figures in these columns represents determinations made upon the water before it had been filtered through filter paper.

MERRIMACK RIVER.

Chemical Examination of Water from the Merrimack River above Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
8079	Oct. 13	Oct. 14	Distinct.	Cons., gray.	0.30	6.00	1.50	.0030	.0294	.0218	.0076	.38	.0090	.0002	1.6
8080	Oct. 13	Oct. 14	Distinct.	Cons., gray.	0.30	6.10	2.50	.0036	.0286	.0198	.0088	.38	.0090	.0002	1.6
8223	Nov. 5	Nov. 6	Slight.	Cons.	0.30	*6.25 5.75	*2.65 2.40	.0054	.0342	.0230	.0112	.42	.0100	.0003	1.8
8224	Nov. 5	Nov. 6	Slight.	Cons.	0.30	*6.50 5.80	*2.25 1.75	.0054	.0316	.0206	.0110	.39	.0100	.0003	1.7
Av.	....	....	....	....	0.30	5.91	2.04	.0043	.0309	.0213	.0096	.39	.0095	.0002	1.7

Odor, distinctly musty.——The samples were collected from the river about one mile above the Boston and Maine Railroad bridge at Haverhill and opposite the base-ball park. Nos. 8079 and 8223 were collected from the north half of the river and Nos. 8080 and 8224 from the south half.

* These determinations were made upon the water before it had been filtered through filter paper.

Chemical Examination of Water from the Merrimack River below Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.	1891.													
8078	Oct. 13	Oct. 14	Distinct.	Cons., gray.	0.20	5.75	1.75	.0026	.0304	.0220	.0084	.37	.0100	.0002	1.7
8081	Oct. 13	Oct. 14	Slight.	Cons., gray.	0.25	5.55	2.00	.0040	.0244	.0206	.0038	.32	.0100	.0002	1.6
8225	Nov. 5	Nov. 6	Slight.	Slight, white.	0.30	*6.00 5.60	*1.65 1.45	.0030	.0262	.0188	.0074	.37	.0100	.0003	1.7
8226	Nov. 5	Nov. 6	Slight.	Cons.	0.30	*6.25 5.30	*2.30 1.90	.0030	.0276	.0192	.0084	.38	.0090	.0003	1.8
Av.	....	....	....	....	0.26	5.55	1.77	.0031	.0271	.0201	.0070	.36	.0097	.0002	1.7

Odor, distinctly musty.——The samples were collected from the river below Haverhill at the upper end of Porter's island. Nos. 8078 and 8225 were collected from the north half of the river and the others from the south half.

These determinations were made upon the water before it had been filtered through filter paper.

NASHUA RIVER.

Chemical Examination of Water from Stony Brook near its Mouth at North Chelmsford.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1891.														
6880	Jan. 9	Jan. 10	Distinct.	Slight.	0.60	4.05	1.25	.0042	.0344	.0216	.0128	.25	.0250	.0001	1.6
7058	Feb. 24	Feb. 25	Slight.	Cons.	0.50	3.50	1.10	.0006	.0154	.0100	.0054	.13	.0200	.0000	1.3

Odor, vegetable.—— The samples were collected from the brook a short distance above its junction with the Merrimack River. No. 6880 was collected at the railroad bridge and No. 7058 at the highway bridge.

Microscopical Examination.

No. 6880. Diatomaceæ, *Asterionella*, 8; *Diatoma*, 7; *Nitzschia*, 15; *Synedra*, 7. Fungi, *Crenothrix*, 24. Infusoria, *Dinobryon*, 2; *Peridinium*, pr. Vermes, *Rototorian ova*, 1. Miscellaneous, *Zoöglœa*, 352. Total, 416.

No. 7058. Diatomaceæ, *Diatoma*, 6; *Melosira*, 1; *Nitzschia*, 10; *Synedra*, 3; *Tabellaria*, 4. Fungi, *Crenothrix*, pr. Infusoria, *Peridinium*, pr. Miscellaneous, *Zoöglœa*, 1,132. Total, 1,156.

Nashua River.

An examination of the north and south branches of the Nashua River was made Oct. 12–15, 1891, with special reference to the effect of the discharge of sewage and manufacturing refuse into these streams at Fitchburg and Clinton respectively.

Statistics of the area and population of the water-shed of the Nashua River and its tributaries, together with the general topographical features of the basin and the various sources of pollution are fully set forth in the special report of the Board on the Examination of Water Supplies, 1890, pp. 467–473, and will not be repeated here.

The tables of population contained in that report were based upon the census of 1885. A comparison with the census of 1890 shows that the population, particularly on the North Branch, has been increasing very rapidly of recent years. The following table shows the growth of population in Fitchburg, Leominster and Clinton and in the entire water-shed of each branch of the river.

NASHUA RIVER.

Locality.	Population in 1885.	Population in 1890.	Per cent. increase, 1885 1890.
Fitchburg,	15,375	22,037	43.3
Leominster,	5,297	7,269	37.2
North Branch at mouth,	24,873	33,576	35.0
Clinton,	8,945	10,424	16.5
South Branch at mouth,	17,030	18,582	9.1

The North Branch, in the south-westerly corner of Fitchburg, is a small stream which is soon joined by two important branches from the north, known as Whitman's River and Phillips Brook. The latter is also known as the Nookagee or Ashburnham River. From Crocker & Burbank's paper mill, located on the main stream above both of these branches, at the extreme upper end of the city, to the Falulah paper mill, at the extreme lower end, the distance is about 6.3 miles and the total fall of the stream is approximately 275 feet. The valley of the stream in Fitchburg is quite narrow, the hills approaching it closely in many places. Within the valley are located nearly all the population of the city and the manufacturing establishments. The city had on Dec. 1, 1891, 16.34 miles of sewers which discharged directly into the river, and the refuse from the factories is generally disposed of in the same way. The manufactories comprise 13 paper mills, 3 worsted mills, 5 gingham mills, a gas works and many other establishments of various kinds. Most of the paper mills are located at the upper end of the city.

At mill No. 3 of the Fitchburg Paper Company, which is located just below the mouth of Phillips Brook and below eight other paper mills, the river showed marked traces of pollution both in appearance and by chemical analysis; this was due chiefly to the polluting matters discharged from the mills, as there was only one sewer, about 2,000 feet in length, discharging into the stream above this mill. The water at this point is no longer used in some of the manufacturing processes without filtration, and though it is still used in the boilers, it is said to be somewhat unsatisfactory for the purpose. Below this point the river grew rapidly worse in its course

through the city, owing largely to the domestic sewage turned into it, and in the lower part of the city and in the valley below it had an offensive odor.

Below the city the valley is somewhat wider and the river is joined by Baker's Brook, a considerable tributary from the north, draining an area about one-fourth the size of that drained by the main stream. There are no manufactories of consequence on this stream and very few inhabitants on its water-shed, so that the water is almost entirely free from sewage pollution. The summer flow is doubtless considerably less per square mile of water-shed in dry seasons than that of the Nashua, as there are no ponds or storage reservoirs on its water-shed, excepting those from which the city draws its supply of water.

Below Baker's Brook the river flows for a mile through meadow land where there are no houses in the vicinity of the stream, and is again ponded at North Leominster, about two miles below the last mill in Fitchburg. At this point the odor of the stream was offensive and its appearance black and dirty, it being but little changed in these respects from its condition in the lower part of Fitchburg.

The next point of examination was at Lancaster, about nine miles below North Leominster and just above the confluence of the North and South Branches. The current at this place was very sluggish, and the river, though still somewhat dirty in appearance, had improved considerably and only a very slight odor was noticeable.

Between the mouth of Baker's Brook and the confluence of the North and South Branches at Lancaster, the flow of the North Branch is increased by a number of small tributaries, most of which are free from pollution; one of them, however, known as Monoosnoc Brook, flows through the thickly settled portion of the town of Leominster and receives the sewage from a portion of the population and manufacturing refuse from mills, in consequence of which it is little better than the North Branch itself at the point where the streams join. There are also several mills and factories on the main stream, some of which discharge into it sewage and manufacturing refuse of various kinds. The increase in drainage area from the mouth of Baker's Brook to the mouth of the North Branch amounts to 64 per cent.

On Oct. 15, 1891, one of the days when samples of water were collected for analysis, a measurement was made of the quantity

of water flowing in the river below Fitchburg. This measurement was made at a point between the Duck mill and the Falulah paper mill, at three o'clock in the afternoon, when nearly all the water was passing through the canal. The flow in the river bed, consisting mostly of leakage from the dam, was also measured. The total amount flowing was found to be at the rate of 86.06 cubic feet per second, equal to 1.35 cubic feet per second per square mile of water-shed. These results were obtained when the Duck mill was running, and, as this mill found it necessary to shut down at times during the day in order to allow the water to accumulate in the millpond, the measurement represents much more than the average flow during working hours.

The water-shed of the South Branch above Clinton contains no large towns, resembling in this respect that of the North Branch above Fitchburg. There are, however, several manufacturing establishments along the river and its tributaries, which contribute polluting matters to the stream; but when the water reaches Clinton, the pollution is scarcely perceptible by chemical analysis.

The town of Clinton is situated about two miles above the confluence of the North and South Branches, and lies mostly in the valley of a small tributary of the South Branch, known as Coachlace Brook, which runs parallel with the river for a short distance and empties into it just below the town. On the river within the town there are two dams; the upper one furnishes power for the Lancaster mills and the lower one for a much smaller factory. On Coachlace Brook the only important establishments are the factories of the Bigelow Carpet Company. The brook is very much polluted by sewage and manufacturing wastes, but has been somewhat improved by the construction of a sewerage system having its outlet into the river, and by the filling of Counterpane Pond, a very foul millpond in the middle of the town. At the end of 1891 there were five and one-fourth miles of sewers discharging directly into the river below the town. The current in the river at the point of discharge is somewhat sluggish, as the water backs up to this point from a dam in South Lancaster, about half a mile below. On Oct. 12, 1891, the water was considerably discolored for several hundred feet below the sewer, but at the dam it showed no discoloration and there was little or no odor.

Below the dam the current is quite rapid to the mouth of the stream and no polluting matter is discharged into it in this portion

of its course. The flow of this branch was measured on Oct. 13, 1891, at its mouth, and was found to be 55.8 cubic feet per second, equivalent to 0.43 cubic feet per second per square mile of watershed. The measurement was made during the day and represents the flow when the mills were running. Gauge readings taken early in the morning and late at night indicated that the night flow was much less than the day flow.

Tables giving in detail the results of the examinations will be found on subsequent pages, beginning on page 312, and only the salient features will be referred to here.

In making a comparison of the character of the water at different points upon the streams, a series of analyses made by the State Board of Health in 1876 can also be used, so as to show not only the change in the character of the water from one place to another, then and at the present time, but also the extent to which the pollution has increased in the past fifteen years.

The first comparison will be made of three points on the North Branch of the river, the first one at the extreme upper end of Fitchburg, where the water is polluted only by a few mills still further up stream, the second at a point below the Falulah paper mill, the last mill in Fitchburg, where the stream reaches its point of maximum pollution, and the third at the mouth of the stream, about eleven miles below, where it has had an opportunity to recover to a considerable extent by dilution with the water of cleaner tributaries, by the deposition of suspended matter, and by other processes of purification which take place in a flowing stream.

Comparison of Analyses at Three Points on the North Branch of the Nashua River.

Locality.	Total Residue.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
1876.				
Above Fitchburg,	2.64	.0037	.0117	.15
Below Fitchburg,	7.46	.0184	.0259	.48
At mouth,	7.16	.0056	.0173	.96
1891.				
Above Fitchburg,	7.50	.0214	.0313	.45
Below Fitchburg,	20.50	.0824	.0786	1.24
At mouth,	10.20	.0365	.0266	1.18

NASHUA RIVER.

On the South Branch the best comparison can be made between the condition of the river just above the Lancaster Mills at Clinton and at the mouth of the stream. The comparisons for 1876 and 1891 are given in the following table: —

Comparison of Analyses at Two Points on the South Branch of the Nashua River.

Locality.	Total Residue.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
1876.				
Above Clinton, ...	4.52	.0088	.0179	.16
Below Clinton at mouth of stream, . .	3.88	.0061	.0160	.24
1891.				
Above Clinton, ...	4.17	.0010	.0305	.29
Below Clinton at mouth of stream, . .	6.01	.0141	.0338	.39

All of the samples given in these tables were collected when the river was very low, with the exception of samples obtained in 1876 below Fitchburg and above Clinton. These were collected a few days after a heavy rain when the river was above its ordinary summer level.

In a comparison of analyses such as these, the total dissolved residue and chlorine furnish a good measure of the amount of polluting matter put into the stream, because, once in the stream, they are not removed to any considerable extent by any processes of decomposition or purification, other than the purification which comes from dilution with purer water. Free ammonia is a characteristic ingredient of fresh sewage and where a stream is seriously polluted, as in the cases under consideration, it is the best index of the amount of sewage contamination. When a stream is only slightly polluted it sometimes disappears very rapidly, and even in a seriously polluted stream it diminishes as the distance from the point of pollution increases. The amount of nitrogenous organic matter actually in the water is best indicated by the albuminoid ammonia. This substance, however, may be derived from the organic matter of the sewage or from manufacturing wastes which are not easily decomposable, and considerable is often found even in unpolluted waters. While, therefore, an increase in albuminoid ammonia may

be expected to accompany the pollution of a stream, it may represent matters which are objectionable to a varying degree.

In the table relating to the North Branch it will be seen that in 1876 there is a marked increase in all of these constituents from a point above Fitchburg to one below it, and a subsequent partial recovery as the water passes to the mouth of the stream. In 1891 the water above Fitchburg is much more polluted than in 1876, and below Fitchburg the pollution has increased to a very much greater extent so that this portion of the river is now in a foul condition in dry weather. At the mouth of the stream the analysis of 1891 shows a much greater degree of pollution than that of 1876.

The analyses of the South Branch, above and below Clinton, in 1876 do not give any decided indications of pollution, but the analyses of 1891 show such pollution to a marked degree except in the amount of albuminoid ammonia, of which there is only a very slight increase. This seems to be due to the abnormal amount of albuminoid ammonia found in the samples collected above Clinton, the amount being much greater than in other samples taken on the same days a short distance further down stream, and also greater than in the regular monthly samples taken from the river above Clinton from June, 1887, to June, 1889. It is obvious, however, that the South Branch below Clinton is very much less polluted than the North Branch just below Fitchburg, and even at the confluence of the streams the South Branch is now less polluted than the North Branch.

The character of the water in the South Branch varies more from time to time than that in the North Branch, so that at times the analysis of its water shows nearly as much pollution as that of the North Branch. This may be seen by the following comparison, in which the highest determinations were selected in each case.

Comparison of Analyses of the North and South Branches of the Nashua River at their Confluence, selecting from Each Series of Analyses the Highest Determinations.

Locality.	Total Residue.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.
North Branch, ...	12.30	.0684	.0360	1.49
South Branch, ...	7.35	.0550	.0396	0.71

NASHUA RIVER.

Chemical Examination of Water from the North Branch

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved	Suspended.
		1891.	1891.									
1	8090	Oct. 14, 2.05 P.M.	Oct. 15	Dis't, milky.	Slight.	0.70	8.30	7.50	.80	2.30	2.00	.30
2	8113	Oct. 15, 8.20 A.M.	Oct. 16	Dec'd, milky.	Cons., gray.	0.70	9.60	7.50	2.10	3.50	2.50	1.00
3	8115	Oct. 15, 8.50 A.M.	Oct. 16	Slight, milky.	Slight, gray.	0.70	4.80	3.50	1.30	1.10	1.00	.10
4	8087	Oct. 14, 2.25 P.M.	Oct. 15	Dis't, milky.	Cons., gray.	0.50	7.10	4.90	2.20	2.00	1.80	.20
5	8114	Oct. 15, 8.40 A.M.	Oct. 16	Dis't, milky.	Consid'ble.	0.70	5.50	4.90	.60	2.20	1.70	.50
6	8091	Oct. 14, 2.30 P.M.	Oct. 15	Dec'd, milky.	Cons., gray.	0.70	15.80	10.90	4.90	4.40	2.90	1.50
7	8116	Oct. 15, 9.00 A.M.	Oct. 16	Dec'd, milky.	Cons., gray.	0.50	9.90	7.30	2.60	3.70	2.50	1.20
8	8092	Oct. 14, 2.35 P.M.	Oct. 15	Dec'd, milky.	Cons., gray.	0.70	15.80	11.70	4.10	4.60	3.10	1.50
9	8117	Oct. 15, 9.10 A.M.	Oct. 16	Dec'd, milky.	Cons., gray.	0.70	11.30	8.20	3.10	4.60	3.50	1.10
10	8088	Oct. 14, 2.50 P.M.	Oct. 15	Slight.	Consid'ble.	0.40	5.90	3.70	2.20	1.50	1.00	.50
11	8089	Oct 14, 3.00 P.M.	Oct. 15	Slight, milky.	Slight, gray.	0.45	6.20	4.30	1.90	1.80	1.60	.20
12	8118	Oct. 15, 9.25 A.M.	Oct. 16	Dec'd, milky.	Consid'ble.	0.70	9.70	6.30	3.40	2.85	2.85	.00
13	8093	Oct. 14, 3.10 P.M.	Oct. 15	Dec'd, milky.	Cons., gray.	0.60	11.20	5.60	5.60	4.20	1.40	2.80
14	8119	Oct. 15, 9.35 A.M.	Oct. 16	Dec'd, milky.	Slight, gray.	0.60	13.00	9.40	3.60	2.90	2.50	.40
15	8094	Oct. 14, 3.25 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.60	15.30	10.00	5.30	4.80	3.00	1.80
16	8120	Oct. 15, 9.45 A.M.	Oct. 16	Dec'd, milky.	Consid'ble.	0.70	12.20	10.50	1.70	3.40	2.80	.60
17	8095	Oct. 14, 3.30 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.65	17.90	11.50	6.40	4.70	3.70	1.00
18	8121	Oct. 15, 9.50 A.M.	Oct. 16	Dec'd, milky.	Cons., gray.	0.60	11.40	9.30	2.10	4.00	3.00	1.00
19	8096	Oct. 14, 3.35 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.60	21.50	13.00	8.50	6.60	3.00	3.60
20	8122	Oct. 15, 10.05 A.M.	Oct. 16	Dec'd, milky.	Cons., gray.	0.60	12.10	8.70	3.40	3.80	3.00	.80
21	8097	Oct. 14, 3.40 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.60	20.70	12.00	8.70	5.50	2.60	2.90
22	8123	Oct. 15, 10.15 A.M.	Oct. 16	Dec'd, gray.	Cons., gray.	0.60	12.30	8.50	3.80	4.60	3.60	1.00
23	8103	Oct. 14, 5.50 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.65	18.40	12.20	6.20	5.80	4.90	.90
24	8132	Oct. 15, 12.00 M.	Oct. 16	Thick, muddy.	Cons., gray.	0.60	12.80	9.80	3.00	4.80	3.00	1.80
25	8102	Oct. 14, 5.40 P.M.	Oct. 15	Decided.	Cons., gray.	0.70	16.90	12.70	4.20	5.40	4.20	1.20
26	8131	Oct. 15, 11.55 A.M.	Oct. 16	Thick, muddy.	Cons., gray.	0.70	14.20	10.00	4.20	3.40	2.80	.60
27	8101	Oct. 14, 5.30 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.70	19.30	13.30	6.00	5.70	4.50	1.20
28	8130	Oct. 15, 11.45 A.M.	Oct. 16	Thick, muddy.	Cons., gray.	0.70	18.40	13.50	4.90	4.00	2.50	1.50
29	8100	Oct. 14, 5.20 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.75	21.00	13.80	7.20	6.00	4.90	1.10
30	8129	Oct. 15, 11.30 A.M.	Oct. 16	Thick, muddy.	Cons., gray.	0.70	17.80	12.20	5.60	4.30	3.00	1.30
31	8099	Oct. 14, 5.05 P.M.	Oct. 15	Thick, muddy.	Cons., gray.	0.75	19.90	14.20	5.70	5.10	4.00	1.10
32	8128	Oct. 15, 11.20 A.M.	Oct. 16	Thick, muddy.	Cons., gray.	0.75	17.00	12.40	4.60	5.10	4.20	.90
33	8098	Oct. 14, 4.45 P.M.	Oct. 15	Thick, muddy	Cons., gray.	0.75	22.60	14.00	8.60	5.70	3.40	2.30
34	8127	Oct. 15, 11.00 A.M.	Oct. 16	Thick, muddy.	Cons., gray.	0.75	18.40	12.50	5.90	5.40	4.00	1.40
35	8134	Oct. 15, 5.00 P.M.	Oct. 16	Dis't, scum.	Slight.	0.15	3.80	3.50	.30	1.60	1.40	.20
36	8133	Oct. 15, 4.30 P.M.	Oct. 16	Thick, muddy.	Cons., gray.	0.70	15.30	12.10	3.20	3.80	2.80	1.00

Odor of Nos. 8090 and 8113, decidedly vegetable and mouldy; of Nos. 8115 and 8089, faintly mouldy; of Nos. 8088 and 8118, distinctly musty; of No. 8134, faintly vegetable; of all others, musty and offensive.——The bacteriological samples were collected on October 15, at the same time and place as the

of the Nashua River and its Tributaries at Fitchburg.

[Parts per 100,000.]

Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Bacteria per Cubic Centimeter.	Locality.	
.0216	.0286	.0230	.0056	.46	.0070	.0010	1.3	–	Nashua River at Turnpike Street.	1
.0212	.0340	.0270	.0070	.45	.0050	.0002	1.3	496		2
.0004	.0244	.0202	.0042	.16	.0090	.0002	0.8	468	Whitman's River at Snow Millpond.	3
.0000	.0208	.0186	.0022	.22	.0030	.0025	1.3	–	Whitman's River above lowest dam.	4
.0000	.0188	.0172	.0016	.28	.0100	.0001	1.1	450		5
.0000	.0312	.0254	.0058	.92	.0070	.0012	2.5	–	Nashua River above second dam, below Whitman's River.	6
.0000	.0322	.0236	.0086	.51	.0070	.0005	1.7	7,600		7
.0024	.0430	.0344	.0086	1.10	.0070	.0012	2.9	–	Nashua River above dam at Hanna Paper Mill.	8
.0018	.0356	.0310	.0046	.64	.0050	.0005	2.1	920		9
.0002	.0220	.0158	.0062	.17	.0030	.0000	1.3	–	Phillips Brook above McTaggart's Mill.	10
.0012	.0176	.0110	.0066	.21	.0170	.0000	1.3	–	Phillips Brook above Westminster Street bridge.	11
.0004	.0276	.0202	.0074	.29	.0100	.0005	0.9	946		12
.0032	.0430	.0264	.0166	.40	.0070	.0003	1.4	–	Nashua River at Mill No. 3 of the Fitchburg Paper Company.	13
.0014	.0328	.0248	.0080	.63	.0050	.0005	1.8	7,700		14
.0040	.0466	.0296	.0170	.77	.0070	.0015	2.6	–	Nashua River at flour mill just below the Fitchburg R. R. bridge.	15
.0004	.0422	.0266	.0156	.77	.0070	.0010	2.7	4,600		16
.0024	.0538	.0312	.0226	1.04	.0090	.0020	2.9	–	Nashua River at River Street.	17
.0008	.0484	.0346	.0138	.79	.0070	.0010	2.5	14,200		18
.0040	.0706	.0466	.0240	1.22	.0120	.0000	3.0	–	Nashua River at Rollstone Street.	19
.0004	.0534	.0300	.0234	.81	.0070	.0015	2.6	24,600		20
.0152	.0786	.0406	.0380	1.18	.0100	.0000	2.9	–	Nashua River at first dam below Rollstone Street.	21
.0004	.0562	.0352	.0210	.83	.0050	.0012	2.6	7,400		22
.0358	.0782	.0446	.0336	1.22	.0150	.0002	2.9	–	Nashua River above Water Street.	23
.0088	.0548	.0392	.0156	.98	.0120	.0002	2.6	6,700		24
.0836	.0822	.0486	.0336	1.29	.0220	.0002	2.9	–	Nashua River above Wheelwright's Paper Mill.	25
.0284	.0602	.0364	.0238	1.07	.0150	.0008	2.9	45,600		26
.1060	.0906	.0530	.0376	1.31	.0050	.0002	3.1	–	Nashua River above entrance of Fitchburg Worsted Co.'s Mill.	27
.0630	.0756	.0530	.0226	1.29	.0150	.0010	3.8	60,900		28
.1040	.0866	.0476	.0390	1.37	.0070	.0010	3.5	–	Nashua River above the Duck Mill.	29
.0768	.0764	.0494	.0270	1.41	.0150	.0020	3.1	56,400		30
.0936	.0850	.0472	.0378	1.43	.0120	.0000	3.4	–	Nashua River above Falulah Paper Mill.	31
.0800	.0792	.0488	.0304	1.26	.0150	.0018	2.9	70,000		32
.1000	.0930	.0570	.0360	1.47	.0150	.0050	3.6	–	Nashua River about ¼ mile below Falulah Paper Mill.	33
.0824	.0786	.0484	.0302	1.24	.0050	.0020	3.1	111,600		34
.0000	.0204	.0126	.0078	.38	.0050	.0001	1.3	–	Baker's Brook.	35
.0800	.0558	.0400	.0158	1.24	.0300	.0020	2.8	–	Nashua River above No. Leominster.	36

chemical samples of that date. A more extended description of the localities from which samples were collected than that given in the last column of the table will be found on the following pages.

NASHUA RIVER.

Locality of Samples included in Table on pages 312 and 313.

Nos. 8090 and 8113 were collected from the Nashua River at Turnpike Street, just above Crocker & Burbank's paper mill. The river is considerably polluted by manufacturing refuse above this point but no sewers discharge into it.

No. 8115, from Snow millpond on Whitman's River above the third dam from its mouth and above all mills in Fitchburg.

Nos. 8087 and 8114, from Whitman's River just above the lowest dam. Between this point and the point where No. 8115 was collected this river receives polluting matter from one of Crocker & Burbank's paper mills.

Nos. 8091 and 8116, from the Nashua River above the second dam below Whitman's River. Between this point and the next sampling places above, the river receives polluting matters from three paper mills, one of which is located on Whitman's River at its mouth.

Nos. 8092 and 8117, from the Nashua River at the dam above the Hanna paper mill (Crocker & Burbank). There is one paper mill on the stream between this point and the sampling place next above.

No. 8088, from Phillips Brook at McTaggart's millpond, above all mills in Fitchburg.

Nos. 8089 and 8118, from Phillips Brook near its mouth at a point far enough above the Westminster Street bridge to exclude sewage from a sewer discharging at Westminster Street, and drainage from the Beoli Company's worsted mills. There are two paper mills, a worsted mill and a gingham mill on the stream between this point and the sampling place next above.

Nos. 8093 and 8119, from the Nashua River above mill No. 3 of the Fitchburg Paper Company and just below the mouth of Phillips Brook. Between this point and the next sampling places above, the river receives polluting matter from a paper mill (Crocker & Burbank's), a worsted mill and a sewer.

Nos. 8094 and 8120, from the Nashua River at a flour mill located just below the first railroad bridge below the mouth of Phillips Brook. Between this point and the sampling place next above, the river receives polluting matter from three paper mills and a sewer.

Nos. 8095 and 8121, from the river at River Street, just above the dam of Barstow & Cookson's cotton batting mill. Between this point and the sampling place next above there are two gingham

mills, one of which was not in operation, and a flour mill; also a sewer.

Nos. 8096 and 8122, from the river at Rollstone Street. Between this point and the one just described are two cotton yarn mills, a cotton batting mill, a worsted mill, a machine shop, a gingham mill and two sewers.

Nos. 8097 and 8123, from the river at the first dam below Rollstone Street. Between this point and the sampling place at Rollstone Street, the river receives polluting matter from a sewer and from a gingham mill.

Nos. 8103 and 8132, from the river at the dam just above the Water Street bridge. Between this point and the next sampling place above, three sewers discharge into the river; there are only two mills on the stream within this distance, a machine shop and a flour mill.

Nos. 8102 and 8131, from the Nashua River at the dam above Wheelwright's paper mill. Between this point and the next sampling place above, the river receives sewage from four sewers which receive a large portion, probably nearly half, the sewage of the city. There are also three machine shops and a gas works on the banks of the stream within this distance.

Nos. 8101 and 8130, from the river at the dam of the Fitchburg Worsted Company, which is next below the dam of the Wheelwright paper mill. Between these two points the river receives the drainage from the paper mill and sewage from a small sewer.

Nos. 8100 and 8129, from the canal leading to the Duck Mill, just before the water passes the screens. The only important pollution entering the river between this point and the next sampling place above comes from the Fitchburg Worsted Company's mill.

Nos. 8099 and 8128, from the canal at the Falulah paper mill just before passing the screens. Between this point and the sampling place above, the river receives pollution from a sewer and from the Duck Mill.

Nos. 8098 and 8127, from the river about half a mile below the Falulah paper mill.

No. 8134, from Baker's Brook at Summer Street bridge.

No. 8133, from the river at the Hamilton Street bridge, just above North Leominster.

NASHUA RIVER.

Chemical Examination of Water from the North Branch of the Nashua River, just above its Confluence with the South Branch, at Lancaster.

[Parts per 100,000.]

Number.	Date and Hour of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
								Albuminoid.						
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1891.													
7816	Aug. 14, 11.00 A.M.	Slight.	Slight.	0.60	8.60	2.10	.0136	.0240	.0204	.0036	0.87	.0300	.0020	2.7
7825	Aug. 18, 4.50 P.M.	Slight.	Slight.	0.45	8.65	2.05	.0198	.0238	.0212	.0026	0.88	.0350	.0030	2.6
7999	Oct. 2, 10.20 A.M.	Slight.	Slight.	0.30	10.96	2.30	.0516	.0238	.0234	.0004	1.49	.0400	.0015	3.2
8022	Oct. 6, 9.55 A.M.	V. sl't.	Slight.	0.40	10.55	1.70	.0172	.0248	.0210	.0038	1.36	.0350	.0010	3.0
8041	Oct. 12, 9.45 A.M.	Dist't.	Cons.	0.50	9.40	1.60	.0506	.0346	.0284	.0062	1.12	.0350	.0002	2.5
8042	Oct. 12, 4.20 P.M.	Slight.	Slight.	0.50	11.05	2.55	.0648	.0360	.0322	.0038	1.24	.0250	.0001	2.9
8069	Oct. 13, 10.05 A.M.	Slight.	V. sl't.	0.50	11.20	2.35	.0684	.0230	.0216	.0014	1.30	.0350	.0005	3.2
8083	Oct. 14, 9.06 A.M.	Slight, milky.	V. sl't, gray.	0.45	12.30	2.80	.0320	.0286	.0264	.0022	1.33	.0300	.0020	3.0
8104	Oct. 14, 3.40 P.M.	Slight, milky.	V. sl't.	0.50	12.60* 11.30	3.40* 3.00	.0388	.0326	.0284	.0042	1.30	.0300	.0001	2.9
8126	Oct. 15, 5.00 P.M.	Dist't. Scum.	Slight.	0.50	10.60* 9.80	3.20* 8.00	.0312	.0336	.0274	.0062	1.05	.0300	.0010	2.3
8135	Oct. 15, 11.00 A.M.	Slight.	Slight, rusty.	0.45	10.30* 9.50	2.20* 2.00	.0256	.0216	.0180	.0036	1.06	.0300	.0005	2.7
Av.	....	....	....	0.46	10.20	2.25	.0365	.0266	.0235	.0031	1.18	.0331	.0012	2.8

* These determinations were made upon the unfiltered water.

Odor of No. 7825, none; of No. 8135, vegetable; of the others, mouldy or musty, and sometimes also disagreeable.——The samples were collected from the river at the railroad bridge, a short distance above its mouth. All of the samples were examined on the day after collection. A bacteriological examination of a sample of water collected at the same time and place as No. 8069 showed the presence of 451 bacteria per cubic centimeter.

The amount of oxygen consumed was determined for the last three samples with the following results:—

	Unfiltered.	Filtered.
No. 8104,	.7200	.6550
8126,	.5820	.5380
8135,	.5400	.5160

NASHUA RIVER.

Chemical Examination of Clinton Sewage.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.
	1891.													
8070	Oct. 13	Oct. 14	Thick.	Heavy, brown.	Deep yellow, turbid.	*614.5 384.2	*312.0 226.4	5.1600	5.2700	2.9500	2.3200	11.55	.0200	.0000

* These determinations were made upon the unfiltered sewage.

The sample was collected from the sewer at its outlet, one-half being collected at 10 A.M. and the remainder at 4.20 P.M. A bacteriological examination of sewage collected at 10 A.M. gave 1,782,000 bacteria per cubic centimeter.

Chemical Examination of Water from the South Branch of the Nashua River at Clinton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8047	Oct. 12	Oct. 13	Distinct.	Heavy.	0.30	4.05	1.05	.0016	.0324	.0188	.0136	.29	.0070	.0000	1.1
8067	Oct. 13	Oct. 14	Slight.	Cons.	0.25	4.30	1.90	.0004	.0286	.0204	.0082	.30	.0090	.0005	1.4
8048	Oct. 12	Oct. 13	Distinct.	Slight.	0.30	6.05	1.30	.0040	.0292	.0200	.0092	.89	.0150	.0008	2.1
8068	Oct. 13	Oct. 14	Slight.	V. slight.	0.30	4.90	1.00	.0004	.0136	.0094	.0042	.32	.0120	.0002	1.6

Odor, distinctly musty or vegetable. —— The first two samples were collected from the river about half a mile above Clinton, on the right bank of the stream; Nos. 8048 and 8068, from the river about 300 feet above the point where the Clinton sewerage system discharges into the stream.

Bacteriological examinations of samples collected at the same time and place as Nos. 8067 and 8068 gave, respectively, 138 and 1,820 bacteria per cubic centimeter.

Chemical Examination of Water from Coachlace Brook at Clinton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.														
8049	Oct. 12	Oct. 13	Slight, milky.	Cons.	0.25	7.95	1.80	.1600	.0392	.0242	.0150	.80	.0800	.0020	1.9
8050	Oct. 12	Oct. 13	Decided, milky.	Cons.	0.35	9.85	2.50	.1664	.0618	.0422	.0196	.95	.0800	.0040	2.1

Odor, musty and offensive. —— The samples were collected from the brook near its mouth. No. 8049 was collected at 10.50 A.M. and No. 8050 at 3.50 P.M.

A bacteriological examination of a sample of water collected at the same time and place as No. 8050 gave 5,760 bacteria per cubic centimeter.

NASHUA RIVER.

Chemical Examination of Water from the South Branch of the Nashua River, just above its Confluence with the North Branch, at Lancaster.

[Parts per 100,000.]

Number.	Date and Hour of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1891.													
7817	Aug. 14, 11.30 A.M.	Dist't.	Cons.	0.60	6.30	2.00	.0206	.0362	.0246	.0116	.31	.0020	.0003	1.3
7824	Aug. 18, 4.30 P.M.	Dist't.	Cons.	0.40	5.30	2.20	.0044	.0294	.0214	.0080	.32	.0030	.0002	1.6
8000	Oct. 2, 10.05 A.M.	Dec'd.	Cons., rusty.	0.50	6.10	2.50	.0050	.0366	.0258	.0108	.33	.0070	.0001	1.6
8023	Oct. 6, 9.45 A.M.	Dist't.	Cons.	0.40	6.00	2.10	.0248	.0334	.0224	.0110	.38	.0100	.0006	1.6
8043	Oct. 12, 9.20 A.M.	Dist't.	Cons	0.40	5.95	1.70	.0318	.0306	.0264	.0042	.59	.0350	.0001	1.8
8044	Oct. 12, 11.30 A.M.	Dist't.	Cons.	0.40	5.35	1.95	.0356	.0342	.0256	.0086	.53	.0150	.0001	1.6
8045	Oct. 12, 2.15 P.M.	Dist't.	Cons.	0.35	5.60	1.80	.0550	.0266	.0226	.0040	.50	.0150	.0000	1.6
8046	Oct. 12, 4.35 P.M.	Dist't, milky.	Cons.	0.40	6.50	1.70	.0292	.0378	.0290	.0088	.71	.0150	.0000	1.8
8065	Oct. 12, 7.00 P.M.	Dist't, milky.	Cons., gray.	0.40	6.75	2.30	.0202	.0348	.0262	.0086	.54	.0300	.0003	1.8
8063	Oct. 13, 7.00 A.M.	Dist't, milky.	Slight, gray.	0.40	7.35	3.00	.0036	.0326	.0276	.0050	.41	.0090	.0005	1.6
8062	Oct. 13, 10.00 A.M	Dist't, milky.	Slight, gray.	0.40	6.55	2.95	.0058	.0292	.0224	.0068	.42	.0100	.0001	1.4
8064	Oct. 13, 1.00 P.M.	Dist't, milky.	Slight, gray.	0.40	6.35	3.45	.0186	.0308	.0254	.0054	.42	.0200	.0008	1.6
8066	Oct. 13, 4.00 P.M.	Dist't, milky.	Cons., gray.	0.40	7.30	3.40	.0212	.0320	.0224	.0096	.41	.0120	.0003	1.6
8082	Oct. 14, 9.40 A.M.	Dist't, milky.	Slight, gray.	0.40	5.30	1.30	.0002	.0330	.0218	.0112	.39	.0070	.0002	1.3
8105	Oct. 14, 4.10 P.M.	Dist't, milky.	Cons., gray.	0.50	7.10* 6.50	2.90* 2.60	.0130	.0396	.0322	.0074	.43	.0120	.0015	1.7
8136	Oct. 15, 11.20 A.M.	Dist't, milky.	Slight, rusty.	0.40	6.93* 5.40	2.30* 2.00	.0018	.0338	.0204	.0134	.85	.0100	.0002	1.4
8125	Oct. 15, 4.45 P.M.	Dec'd, milky.	Slight, gray.	0.50	6.40* 5.80	2.10* 1.80	.0084	.0348	.0230	.0118	.42	.0070	.0008	1.9
Av.	....	....	....	0.45	6.01	2.22	.0141	.0338	.0242	.0096	.39	.0093	.0003	1.6

* These determinations were made upon the unfiltered water.

Odor, generally musty, sometimes offensive.——The samples were collected from the river, a short distance above its mouth, and were examined on the day after collection, except No. 8065, which was examined two days after.

A bacteriological examination of a sample of water collected at the same time and place as No. 8062 gave 10,485 bacteria per cubic centimeter.

The amount of oxygen consumed was determined in the last three samples with the following results: —

	Unfiltered.	Filtered.
No. 8105, ...	.5530	.5400
8136, ...	.5240	.4700
8125, ...	.4790	.4790

Neponset River.

Mention is made on page 57 of this volume of a complaint made by a citizen of Canton with regard to the condition of the Fowl Meadows, which cover a very large area in the central portion of the Neponset basin. It is averred in this complaint that these meadows are at times the source of a most unbearable stench and the direct cause of much sickness. On this account and because a preliminary examination showed that the upper portion of the stream was very seriously polluted, the Board instituted an investigation into the condition of the river and the sources of its pollution, and also caused a circular to be sent to the physicians in the valley, asking whether, in their opinion, "the present condition of the Neponset River and its affluents and of the Fowl Meadows has an appreciable influence on the health of the people residing in the vicinity." A digest of the replies to this circular will be found in another part of this volume.

The valley of the Neponset River has twice before been the subject of extended examinations by the State authorities, first by the State Board of Health in 1875, and subsequently by the Massachusetts Drainage Commission* in 1885. In addition to these examinations, a description of the Neponset River basin with statistics relating to its pollution and analyses of its water may be found in the special report of the State Board of Health on the Examination of Water Supplies, 1890, pp. 482–487, and in the twenty-second annual report of the Board, 1890, pp. 311, 312.

The present examination repeats that made by the Massachusetts Drainage Commission, thereby showing the changes which have taken place in the past six years, and includes, in addition, chemical, microscopical and bacteriological examinations of the water at various points, and measurements of the flow of the stream near the point where the pollution is greatest.

Description of the Neponset Basin.

The streams and principal sources of pollution in the valley of the Neponset are shown on an accompanying map. The river rises in the Neponset Reservoir in Foxborough, and flows thence in a generally

* See report of a Commission appointed to consider a General System of Drainage for the valleys of the Mystic, Blackstone and Charles Rivers, 1886, pp. 76-95.

NEPONSET RIVER.

north-easterly direction to Dorchester Bay, draining an area of 114.1 square miles. The Fowl Meadows, already mentioned, are a prominent feature of the Neponset basin, as they border the stream for about seven miles in the middle portion of its course, and comprise an area of 5.15 square miles, as measured from the topographical map of the State. The remainder of the water-shed is for the most part hilly and rolling, some of the hills, notably the Blue Hill range in Canton and Milton, being high and steep.

Beginning at the upper end of the river, we find first a portion about ten and one-half miles in length, extending from the Neponset Reservoir to the upper end of the meadows, and having in this distance a fall of about two hundred and twenty feet. On this portion of the stream there are many factories and mills which turn a large amount of polluting matter into it, making the part below them more highly polluted by manufacturing refuse than any other portion of the river.

In the middle portion of its course the river meanders with a sluggish current through the meadows, which are generally wet throughout the year, and the water in passing through them improves in quality by dilution with the water from purer tributaries, by the deposition of suspended matters, by the interception of floating substances, and by other processes of purification which take place in a flowing stream. It is, however, far from being pure water when it reaches the lower end of the meadows.

In the lower portion of its course the river has a moderate amount of fall, so that there are several mills upon it, and the population near it is much more dense than in the upper portion of the valley.

There are two principal affluents, — the east branch, which with several small tributaries furnishes power for a large number of factories and mills in Sharon, Stoughton and Canton and enters the main river toward the upper end of the Fowl Meadows, and Mother Brook, which flows through East Dedham and Hyde Park and enters the main river about a mile and a half below the Meadows. Mother Brook is a channel, partly natural and partly artificial, which connects the Charles and Neponset rivers and is legally entitled to receive one-third of the flow of the former stream. As the Charles River at this point drains an area of 198.6 square miles, Mother Brook may be considered as having, besides its own small water-shed, an additional water-shed of 66.2 square miles. On

account of the large quantity of water and the rapid fall, this stream, although only about three miles long, furnishes power to several large mills, which discharge into it much polluting matter.

The Neponset basin includes the whole or considerable portions of the towns of Walpole, Sharon, Stoughton, Canton, Norwood, Dedham, Hyde Park and Milton, the Dorchester district of Boston, and very small portions of the towns of Medfield, Dover, Foxborough, Randolph and Quincy; but, as the included portions of these latter towns are inhabited only by a scattering population which does not seriously pollute the streams, they will not be again referred to. Of the former places all but Walpole are provided with a public water supply, but there is no general system of sewerage in any of them with the exception of Dorchester. There are a few public sewers in Milton and some private drains in other places. All but one of the Dorchester sewers discharging into the river enter the tidal portion below the last dam. The sewage from the lower portion of this district will all be diverted from the river as soon as an intercepting sewer which is now being constructed as far as Milton Lower Mills, and a branch sewer to the village of Neponset, are completed and put in operation.

The population of all the towns in the valley increased considerably in the five years from 1885 to 1890. Excluding Dorchester, the average increase in the towns under consideration during this period was sixteen per cent. The increase in the towns on the east branch of the river, viz., Sharon, Stoughton and Canton, averaged fourteen per cent., and in the towns on the upper portion of the main stream, Walpole and Norwood, eighteen per cent. The towns in the lower portion of the valley, Dedham, Hyde Park and Milton, show an increase of sixteen per cent. In the portion of Dorchester within the water-shed of the Neponset the increase was much greater than in the other places, but not quite so great as in the whole of Dorchester, where the increase was forty-three per cent.

There are several reservoirs in the valley which tend to maintain the flow of the stream in dry weather; their united capacity, however, is not very large, so that the flow becomes small in dry seasons. The Neponset Reservoir, which covers an area of 454 acres, as measured from the State map, and from which eight feet of water can be drawn, is the only reservoir on the upper portion of the main river. On the east branch there are two large reservoirs, Massa-

poag Lake in Sharon and Reservoir Pond in Canton. Ponkapoag Lake in Canton is the only other reservoir of importance within the water-shed of the river. As Mother Brook receives practically all of its water from the Charles River, it is subject to the fluctuations of flow in that stream, and the flow becomes very small in dry seasons.

The flow of the upper portion of the Neponset River was measured on Wednesday and Thursday, Aug. 12 and 13, 1891, at a point below the ink works, and the amount flowing during the daytime was found to average 12.3 cubic feet per second, equal to 0.34 cubic feet per second per square mile.

The following table gives statistics of drainage areas, population, etc., in the Neponset River basin: —

	Distance above Mouth of River. — Miles.	Drainage Area. — Sq. Miles.	Population. (1890.)	Population per Square Mile.
Neponset River below Spring Brook, Walpole, .	20.0	22.05	-	-
Neponset River at Bird's Paper Mill, East Walpole,	17.7	26.66	-	-
Neponset River above Hawes Brook, Norwood, .	16.6	27.12	2,700	100
Neponset River below Hawes Brook, Norwood, .	16.6	35.04	3,325	95
Neponset River at measuring station below ink works,	15.9	35.67	-	-
Neponset River above mouth of sewer from Smith's tannery, ...	15.5	36.00	-	-
Neponset River below mouth of sewer from Smith's tannery, ...	15.5	37.48	-	-
Neponset River above mouth of east branch, . .	13.5	43.79	6,550	150
East branch at mouth, ...	13.5	30.75	9,350	304
Neponset River below mouth of east branch, . .	13.5	74.54	15,900	213
Neponset River opposite wells of Hyde Park Water Company, ...	6.5	94.83	18,550	196
Neponset River at mouth, ...	0	114.14	83,425	738

Examination of the River Water.

The results of chemical examinations of water collected from various points along nearly the whole length of the Neponset River are given in the table on pages 324 and 325. As the greater number of samples were taken on Aug. 13, 1891, this series is given the first place in the table, the analyses being arranged in the order of their position from the upper to the lower end of the stream.

NEPONSET RIVER.

The first analysis given in the table represents the condition of the water above the village of Walpole, where it is nearly free from pollution. From this point down the increased pollution of the water from point to point to the head of the Fowl Meadows is clearly shown by the analyses. It is not, of course, to be expected that a single series of analyses will show the exact amount of polluting matter put into the stream at each point, because the manufacturing refuse is discharged in varying amounts from time to time, and samples taken at different times at any one place are consequently liable to vary considerably from one another. The amount of organic matter added to the water is best shown by the increase in the loss on ignition and in the albuminoid ammonia. It will be noticed that there is a very large increase in both of these constituents at the paper mills of F. W. Bird & Son and Hollingsworth & Vose. By the analyses of August 13 there is also a large increase at the ink works, but this result appears to be anomalous, as the analysis of the sample collected below the ink works is not confirmed either by a corresponding analysis on August 12, or by the analysis at the next sampling place below on August 13; the latter sample contained smaller amounts of these constituents whereas it should have contained larger amounts on account of the drainage from Smith's tannery which enters the river between these points. The hardness of the water is 1.7 parts per 100,000 above Walpole, and is increased to 11.2 parts per 100,000 by the lime turned into the river at the paper mills. The amount of chlorine in the water is also greatly increased by the paper mill drainage.

The analyses show that the east branch is very much less polluted than the main river at the point where the two streams join, and the main river is consequently improved at this point by dilution with the water from this branch. At the time the samples were collected the tannery of Winslow Brothers which generally turns considerable polluting matter into the river above the ink works through Hawes Brook was doing only a very little work.

In the passage of the water through the meadows to a point opposite the pumping station of the Hyde Park water works there is a further very noticeable improvement, although the water is still very much polluted. From this point to the mouth of the stream the analysis of the water does not change very much.

NEPONSET RIVER.

Chemical Examination of Water

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dissolved.	Total Residue. Sus-pended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Loss on Ignition. Sus-pended.
		1891.										
1	7804	Aug. 13	Aug. 14	V. slight.	Slight.	0.75	-	4.25	-	-	2.05	-
2	7805	Aug. 13	Aug. 14	Slight.	Cons'ble.	0.80	-	7.80	-	-	2.60	-
3	7806	Aug. 13	Aug. 14	Slight.	Cons'ble.	0.75	-	6.10	-	-	2.40	-
4	7807	Aug. 13	Aug. 14	Decided.	Heavy.	1.00	17.70	14.50	3.20	5.80	5.70	0.10
5	7808	Aug. 13	Aug. 14	Decided.	Heavy.	1.00	27.80	23.30	4.50	10.40	7.50	2.90
6	7809	Aug. 13	Aug. 14	Decided.	Heavy.	1.20	26.40	22.60	3.80	7.30	7.90	-
7	7802	Aug. 13	Aug. 14	Decided.	V. heavy.	1.00	32.60	22.80	9.80	12.50	6.20	6.30
8	7812	Aug. 13	Aug. 14	Decided.	V. heavy.	1.50	28.00	23.40	4.60	9.40	6.00	3.40
9	7810	Aug. 13	Aug. 14	Decided.	Heavy.	1.20	24.40	21.90	2.50	6.40	4.40	2.00
10	7813	Aug. 13	Aug. 14	V. slight.	Slight.	1.30	-	8.30	-	-	2.10	-
11	7811	Aug. 13	Aug. 14	Decided.	Heavy.	0.90	16.20	14.10	2.10	5.70	3.60	2.10
12	7814	Aug. 13	Aug. 14	Slight.	Heavy, rusty.	1.20	11.40	11.00	0.40	3.70	3.60	0.10
13	7800	Aug. 13	Aug. 13	Distinct.	Cons'ble.	0.70	11.80	10.20	1.60	4.00	2.70	1.30
14	7795	Aug. 12	Aug. 13	Decided, milky.	Cons'ble.	0.80	20.70	18.50	2.20	5.80	4.30	1.50
15	7796	Aug. 12	Aug. 13	Decided, milky.	Cons'ble.	0.80	25.70	21.40	4.30	7.00	4.90	2.10
16	7797	Aug. 12	Aug. 13	Slight.	Slight.	0.80	-	6.75	-	-	3.05	-
17	7799	Aug. 12	Aug. 13	Distinct.	Cons'ble.	0.80	13.70	13.00	0.70	4.00	3.40	0.60
18	7941	Sept. 16	Sept. 17	Slight.	Slight, rusty.	1.75	-	9.67	-	-	3.80	-
19	7732	July 30	July 31	Distinct.	Cons'ble.	0.75	-	8.15	-	-	2.10	-
20	7841	Aug. 21	Aug. 21	Distinct.	Cons'ble.	0.70	-	11.00	-	-	3.30	-

Odor of Nos. 7804 and 7806, none; of No. 7805, vegetable and unpleasant, becoming musty and disagreeable on heating; of No. 7807, strongly alkaline and soapy; of No. 7809, offensive; of Nos. 7810 and 7812, strongly alkaline; of Nos. 7795, 7796 and 7802, tarry and soapy; of Nos. 7797 and 7813, distinctly vegetable; of Nos. 7799 and 7811, distinctly alkaline and tarry; of Nos. 7814, 7941 and 7942, vegetable; of Nos. 7732, 7800 and 7841, distinctly musty.——The samples were collected as follows: No. 7804, from the Neponset River, where Main Street crosses it just above the village of Walpole; No. 7805, at Stetson's dam, just below the village of Walpole; No. 7806, from the millpond of the paper mill of F. W. Bird & Son, in East Walpole, at entrance to wheel; No. 7807, at the dam of the paper mill of Hollingsworth & Vose, which is the next below the paper mill of F. W. Bird & Son; No. 7808, at the next dam below the mill of Hollingsworth & Vose, at Water Street; No. 7809, at the dam of the printing-ink

from the Neponset River.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Locality.	
	Albuminoid.								
Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
.0004	.0234	.0212	.0022	0.14	.0090	.0004	1.60	Above Walpole.	1
.0000	.0376	.0186	.0190	0.76	.0050	.0002	0.79	Above Stetson's dam.	2
.0000	.0338	.0210	.0128	0.29	.0020	.0002	1.43	Above paper mill of F. W. Bird & Son.	3
.0016	.0848	.0660	.0188	0.76	.0070	.0001	6.71	Above paper mill of Hollingsworth & Vose.	4
.0012	.1140	.0540	.0600	1.76	.0100	.0001	11.20	Below paper mill of Hollingsworth & Vose.	5
.0200	.1270	.0670	.0600	3.44	.0050	.0001	10.00	Below brook from Winslow's tannery.	6
.0200	.1810	.0670	.1140	2.70	.0070	.0003	10.00	Below ink works.	7
.0040	.1650	.0720	.0930	3.09	.0060	.0001	10.15	Below sewer from Smith's tannery, and near head of meadows.	8
.0400	.1300	.0670	.0630	3.12	.0020	.0000	9.71	Above east branch.	9
.0018	.0396	.0280	.0116	0.54	.0050	.0005	1.56	East branch near main river.	10
.0240	.0800	.0460	.0340	2.08	.0070	.0004	5.43	Below east branch.	11
.0208	.0518	.0392	.0126	1.37	.0070	.0002	3.38	At Hyde Park pumping station.	12
.0228	.0482	.0322	.0160	1.12	.0090	.0002	4.16	At Milton Lower Mills.	13
.0100	.1122	.0754	.0368	1.86	.0050	.0000	7.43	Below ink works.	14
.0218	.1212	.0702	.0510	3.94	.0050	.0000	9.43	Below sewer from Smith's tannery, and near head of meadows.	15
.0014	.0374	.0234	.0140	0.48	.0000	.0000	2.34	East branch, near main river.	16
.0100	.0570	.0492	.0078	1.60	.0070	.0012	5.57	Below east branch.	17
.0172	.0501	.0433	.0068	0.95	.0060	.0003	3.12	At Hyde Park pumping station.	18
.0164	.0462	.0312	.0150	1.03	.0180	.0001	3.25	At Milton Lower Mills.	19
.0432	.0472	.0354	.0118	1.40	.0050	.0005	4.29	At Milton Lower Mills.	20

works of Geo. H. Morrill & Co., Pleasant Street, Norwood; this point is below the brook which conveys the drainage from Winslow's tannery to the river; Nos. 7795 and 7802, from the river at a small foot-bridge located about a quarter of a mile below Morrill's ink works, and above the sewer from Smith's tannery; Nos. 7796 and 7812, about 1,000 feet below the outlet of the sewer from Smith's tannery and near the head of the Fowl Meadows; No. 7810, from the river in the meadows just above the mouth of the east branch; Nos. 7797 and 7813, from the east branch just above its mouth; Nos. 7799 and 7811, from the river at Neponset Street, a short distance below the mouth of the east branch; Nos. 7814 and 7941, from the river just above the pumping station of the Hyde Park Water Company; Nos. 7732, 7800 and 7841, from the river at Milton Lower Mills, just above the dam of the Baker Chocolate Company.

NEPONSET RIVER.

Chemical Examination of Water

[Parts per 100,000.]

	Number.	Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
		Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Sus-pended.	Total.	Dissolved.	Sus-pended.
		1891.										
1	7804	Aug. 13	Aug. 14	V. slight.	Slight.	0.75	-	4.25	-	-	2.05	-
2	7805	Aug. 13	Aug. 14	Slight.	Cons'ble.	0.80	-	7.80	-	-	2.60	-
3	7806	Aug. 13	Aug. 14	Slight.	Cons'ble.	0.75	-	6.10	-	-	2.40	-
4	7807	Aug. 13	Aug. 14	Decided.	Heavy.	1.00	17.70	14.50	3.20	5.80	5.70	0.10
5	7808	Aug. 13	Aug. 14	Decided.	Heavy.	1.00	27.80	23.30	4.50	10.40	7.50	2.90
6	7809	Aug. 13	Aug. 14	Decided.	Heavy.	1.20	26.40	22.60	3.80	7.30	7.90	-
7	7802	Aug. 13	Aug. 14	Decided.	V. heavy.	1.00	32.60	22.80	9.80	12.60	6.20	6.30
8	7812	Aug. 13	Aug. 14	Decided.	V. heavy.	1.50	28.00	23.40	4.60	9.40	6.00	3.40
9	7810	Aug. 13	Aug. 14	Decided.	Heavy.	1.20	24.40	21.90	2.50	6.40	4.40	2.00
10	7813	Aug. 13	Aug. 14	V. slight.	Slight.	1.30	-	8.30	-	-	2.10	-
11	7811	Aug. 13	Aug. 14	Decided.	Heavy.	0.90	16.20	14.10	2.10	5.70	3.60	2.10
12	7814	Aug. 13	Aug. 14	Slight.	Heavy, rusty.	1.20	11.40	11.00	0.40	3.70	3.60	0.10
13	7800	Aug. 13	Aug. 13	Distinct.	Cons'ble.	0.70	11.80	10.20	1.60	4.00	2.70	1.30
14	7795	Aug. 12	Aug. 13	Decided, milky.	Cons'ble.	0.80	20.70	18.50	2.20	5.80	4.30	1.50
15	7796	Aug. 12	Aug. 13	Decided, milky.	Cons'ble.	0.80	25.70	21.40	4.30	7.00	4.90	2.10
16	7797	Aug. 12	Aug. 13	Slight.	Slight.	0.80	-	6.75	-	-	3.05	-
17	7799	Aug. 12	Aug. 13	Distinct.	Cons'ble.	0.80	13.70	13.00	0.70	4.00	3.40	0.60
18	7941	Sept. 16	Sept. 17	Slight.	Slight, rusty.	1.75	-	9.67	-	-	3.30	-
19	7732	July 30	July 31	Distinct.	Cons'ble.	0.75	-	8.15	-	-	2.10	-
20	7841	Aug. 21	Aug. 21	Distinct.	Cons'ble.	0.70	-	11.00	-	-	3.30	-

Odor of Nos. 7804 and 7806, none; of No. 7805, vegetable and unpleasant, becoming musty and disagreeable on heating; of No. 7807, strongly alkaline and soapy; of No. 7809, offensive; of Nos. 7810 and 7812, strongly alkaline; of Nos. 7795, 7796 and 7802, tarry and soapy; of Nos. 7797 and 7813, distinctly vegetable; of Nos. 7799 and 7811, distinctly alkaline and tarry; of Nos. 7814, 7941 and 7942, vegetable; of Nos. 7732, 7800 and 7841, distinctly musty.——The samples were collected as follows: No. 7804, from the Neponset River, where Main Street crosses it just above the village of Walpole; No. 7805, at Stetson's dam, just below the village of Walpole; No. 7806, from the millpond of the paper mill of F. W. Bird & Son, in East Walpole, at entrance to wheel; No. 7807, at the dam of the paper mill of Hollingsworth & Vose, which is the next below the paper mill of F. W. Bird & Son; No. 7808, at the next dam below the mill of Hollingsworth & Vose, at Water Street; No. 7809, at the dam of the printing-ink

from the Neponset River.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Locality.	
	Albuminoid.								
Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.			
.0004	.0234	.0212	.0022	0.14	.0090	.0004	1.60	Above Walpole.	1
.0000	.0376	.0186	.0190	0.76	.0050	.0002	0.79	Above Stetson's dam.	2
.0000	.0338	.0210	.0128	0.29	.0020	.0002	1.43	Above paper mill of F. W. Bird & Son.	3
.0016	.0848	.0660	.0188	0.76	.0070	.0001	6.71	Above paper mill of Hollingsworth & Vose.	4
.0012	.1140	.0540	.0600	1.76	.0100	.0001	11.20	Below paper mill of Hollingsworth & Vose.	5
.0200	.1270	.0670	.0600	3.44	.0050	.0001	10.00	Below brook from Winslow's tannery.	6
.0200	.1810	.0670	.1140	2.70	.0070	.0003	10.00	Below ink works.	7
.0040	.1650	.0720	.0930	3.09	.0060	.0001	10.15	Below sewer from Smith's tannery, and near head of meadows.	8
.0400	.1300	.0670	.0630	3.12	.0020	.0000	9.71	Above east branch.	9
.0018	.0396	.0280	.0116	0.54	.0050	.0005	1.56	East branch near main river.	10
.0240	.0800	.0460	.0340	2.08	.0070	.0004	5.43	Below east branch.	11
.0208	.0518	.0392	.0126	1.37	.0070	.0002	3.38	At Hyde Park pumping station.	12
.0228	.0482	.0322	.0160	1.12	.0090	.0002	4.16	At Milton Lower Mills.	13
.0100	.1122	.0754	.0368	1.86	.0050	.0000	7.43	Below ink works.	14
.0218	.1212	.0702	.0510	3.94	.0050	.0000	9.43	Below sewer from Smith's tannery, and near head of meadows.	15
.0014	.0374	.0234	.0140	0.48	.0000	.0000	2.34	East branch, near main river.	16
.0100	.0570	.0492	.0078	1.60	.0070	.0012	5.57	Below east branch.	17
.0172	.0501	.0433	.0068	0.95	.0060	.0003	3.12	At Hyde Park pumping station.	18
.0164	.0462	.0312	.0150	1.03	.0180	.0001	3.25	At Milton Lower Mills.	19
.0432	.0472	.0354	.0118	1.40	.0050	.0005	4.29	At Milton Lower Mills.	20

works of Geo. H. Morrill & Co., Pleasant Street, Norwood; this point is below the brook which conveys the drainage from Winslow's tannery to the river; Nos. 7795 and 7802, from the river at a small foot-bridge located about a quarter of a mile below Morrill's ink works, and above the sewer from Smith's tannery; Nos. 7796 and 7812, about 1,000 feet below the outlet of the sewer from Smith's tannery and near the head of the Fowl Meadows; No. 7810, from the river in the meadows just above the mouth of the east branch; Nos. 7797 and 7813, from the east branch just above its mouth; Nos. 7799 and 7811, from the river at Neponset Street, a short distance below the mouth of the east branch; Nos. 7814 and 7941, from the river just above the pumping station of the Hyde Park Water Company; Nos. 7732, 7800 and 7841, from the river at Milton Lower Mills, just above the dam of the Baker Chocolate Company.

NEPONSET RIVER.

Bacteriological Examination of Water from the Neponset River.

PLACE OF COLLECTION.	Aug. 27, 1891.	Sept. 4, 1891.		
	Number of Bacteria Per Cubic Centimeter.	Time of Collection.	Number of Bacteria Per Cubic Centimeter.	
Mill Brook, Walpole, half way between Morey's millpond and mouth of stream,	4,500	9.30 A.M. 9.35 A.M.	750 1,600	1,175
Neponset River, at Stetson's dam, Walpole,	172,944	10.00 A.M. 10.05 A.M.	28,300 20,088	24,194
Neponset River, at highway bridge near Tilton's Station, Walpole, about half way between Stetson's dam and Bird's dam,	15,984	10.20 A.M. 10.25 A.M.	5,400 3,600	4,500
Neponset River, at dam above Bird's paper mill, East Walpole,	591	11.00 A.M. 11.10 A.M.	1,944 1,800	1,872
Neponset River, at Washington Street, East Walpole, about five hundred feet below Bird's dam,	54,720	11.15 A.M. 11.20 A.M.	108,500 126.100	117,300
Neponset River, at next dam below paper mill of Hollingsworth & Vose,	2,440,800	11.30 A.M. 11.30 A.M.	626,400 626,400	626,400
Neponset River, at dam of Morrill's ink works, Norwood,	822,000	12.00 M. 12.05 P.M.	496,800 492,200	494,500
Neponset River, at temporary bridge just below sewer from Smith's tannery,	252,000	12.20 P.M. 12.25 P.M.	229,392 727,200	478,296
Neponset River, at cart bridge just above mouth of east branch,	-	1.15 P.M.	295,200	-
Neponset River, at highway bridge, a short distance below mouth of east branch,	-	2.05 P.M. 2.10 P.M.	27,576 27,504	27,540
Neponset River, opposite pumping station of the Hyde Park Water Works,	-	*9.20 A.M.	444	-

* This sample was collected on September 1.

The bacteriological examination of the river, as given in the table above, is remarkable for the number of bacteria found in the upper portion of the river and particularly below the paper mills. The greatest number found was 2,440,800 per cubic centimeter, on August 27, at the next dam below the Hollingsworth & Vose paper mill. On the same day only about one-tenth as many were found a short distance above the head of the Fowl Meadows, and on September 1 a sample collected below the meadows, opposite the pumping station of the Hyde Park water works, contained but 444 per cubic centimeter.

The microscopical examinations of the samples of water sent into the laboratory do not show any remarkable results as regards numbers, because the plants and animals, which were found in the river in great abundance, were mostly of comparatively large size, and some of them were attached to the bottom of the river. The most prominent feature was an enormous growth of the fungus *Beggiatoa* in the portions of the river extending from the paper mills down to the meadows. The bottom of the river, particularly where there was a swift current, was entirely covered with this grayish growth, and pieces of it were continually breaking off and going down stream,

so that a gallon sample of water collected from the stream generally contained three or four fragments of *Beggiatoa* an inch or more in length. It is noticeable that this abundant growth occurred in about the same portion of the stream that contained the greatest number of bacteria.

After passing into the meadows there was apparently no growth of *Beggiatoa* on the bottom of the stream, and the floating pieces disappeared, probably by deposition. In the middle and lower portions of the meadows there was a very abundant growth of *Lemnæ.* These are plants consisting of more or less roundish green discs not more than a quarter of an inch in diameter, which float upon the surface of the water and have delicate roots projecting from the under side into it. These plants, together with many fragments of water grasses and filamentous algæ which had become detached from the bottom, floated down the stream, and with other floating matters formed a thick scum in the many coves along the river's edge, where they decayed and became more or less offensive.

Another prominent feature of the upper portion of the river was the floating mud which appeared on the surface of the millponds in large dark patches having a green surface, and in smaller masses floating down the stream. Several of these masses were examined microscopically and it was found that they were composed mainly of black mud and *Zoöglœa* with a growth of *Oscillaria* on top which gave the green color and bound the mass together. They also contained large numbers of organisms which are commonly found in river mud, such as worms and large bacteria, together with much *Beggiatoa*, unsheathed *Crenothrix* and *Molds.* These floating masses were found in small numbers as far up stream as Stetson's millpond and were observed in much greater abundance further down stream. Their presence appeared to be due to a large deposit of putrescible matter in the bottom of the millponds, which in the warm weather became covered over and bound together with the growth of *Oscillaria* upon its surface, and was then floated by bubbles of gas resulting from the decomposition of the organic matter. In the millpond of Hollingsworth & Vose the patches of floating matter sometimes covered half an acre or more. As a rule this matter did not exceed an inch in thickness, but near the dam of the ink works a large patch was noticed which measured three inches in thickness. Lumps of this matter could occasionally be seen floating down stream

where the river passes through the Fowl Meadows, and undoubtedly added to the objectionable character of the scum which collected in the coves along this portion of the river.

The statement is made that the meadows are now wet throughout the year, so that the grass which grows upon them cannot be cut and harvested, whereas this condition did not formerly exist. It is claimed by some that the first dam below the meadows in Hyde Park is too high, and that it backs the water up on the meadows, or at least retards the flow of the river through the lower part of the meadows to such an extent that it promotes the deposition of solid matters and the consequent partial obstruction of the channel. A suit was brought by the meadow owners against the proprietors of this dam, but it proved unsuccessful. It is probable that the channel of the river does not have the same carrying capacity that it formerly had, and the manufacturing establishments above the meadows tend to increase the trouble, both by discharging into the river substances which may deposit upon its bed and banks where the flow is sluggish, and also by turning into it other matter, which serves as a fertilizer for the various water plants and makes them grow much more luxuriantly than they otherwise would.

The Neponset River, though not wholly free from pollution by the waste products of human life even in its upper portions, is pre-eminently a river which is polluted by manufacturing wastes. This is very noticeable by the analyses as well as by an inspection of the sources of pollution. It is the intention to make a further study of these manufacturing wastes in order, if possible, to devise some practicable method of preventing the polluting matters from going into the streams.

Since 1885, when the examination of the river was made by the Massachusetts Drainage Commission, a very important source of pollution, viz., the wool-scouring establishment of E. F. Lewis on Mill Brook in Walpole, has been abandoned. The most important sources of pollution which remain upon the upper waters are the two tanneries of Winslow Bros. and the Lyman Smith's Sons Company in Norwood and the two paper mills of F. W. Bird & Co. and Hollingsworth & Vose in East Walpole.

A more detailed statement as to the character of different portions of the river and its tributaries will be found in the following pages, which contain a description of the different sources of pollution.

These descriptions are arranged by towns so as to be readily comparable with similar descriptions given in the report of the Massachusetts Drainage Commission.

Description of Sources of Pollution.

Walpole. — All but a very small portion of this town is within the water-shed of the Neponset River. The town has neither a public water supply nor a sewerage system, and very little sewage matter reaches the stream directly.

The river is augmented in this town by several tributaries, the most important of which are Mill or Mine Brook, which enters the river from the west, and Spring Brook, which enters it from the east. These streams join the river in the village at nearly the same point.

The wool-scouring establishment of E. F. Lewis, on Mill Brook at the outlet of Morey's Pond, one-third of a mile from the Neponset River, which was the most important source of pollution when the river basin was examined in 1885, has, as already stated, been abandoned, the business having been removed to Lawrence in June, 1890.

Near the point where Mill and Spring brooks enter the Neponset River is located the establishment of Bradford Lewis & Son for cleaning cotton waste. About 1,500 pounds of oily waste are cleaned daily. The waste as received contains from twenty to thirty per cent. of dirt and oil, largely petroleum, and is first boiled in soda-ash, then washed, and finally bleached. From 1,000 to 1,200 pounds of soda-ash are used per week. The drainage from this establishment is treated in the same way as in 1885, by turning it into large settling basins in which some of the dirt and oil are intercepted and subsequently burned or otherwise removed, the remainder going into the river. Near by is a paper mill, also owned by Bradford Lewis & Son, in which four tons of dark binders' board are manufactured daily. The polluting matter added to the stream at this place is chiefly soap and dirt washed from the stock.

Opposite the railroad station at Walpole are the works of the Walpole Dye and Chemical Company where about 30 hands are employed, as against 18 in 1885. The conditions at this place are practically the same as in 1885, except that the amount of business has increased. The manufacturing drainage from the works, which is

discharged into Mill Brook near its mouth, has a deep color but does not have an offensive odor. These works are not located directly on a stream but an abundant supply of water is obtained from 23 two-inch tubular wells located in the low ground between the factory and Elm Street.

There are several mills farther up stream which add comparatively little polluting matter to the river, and taking them as a whole it may be said that their effect upon the river is not very different from what it was in 1885.

The factory of the Norton Manufacturing Company was burned in 1889 and has not been rebuilt.

The mill formerly occupied by the Union Mill Company was vacant at the time the river was examined in 1891, but is now (1892) occupied by the Union Mill Company for picking and sorting damaged cotton and sorting cotton waste. About 40 hands are employed who use a privy over the stream.

At the bleachery and dye-house of S. Gray & Co. about 2,500 pounds of yarn are dyed daily, which is an increase of 25 per cent. over the product of 1885.

The next establishment on the river below the cotton waste mill of Bradford Lewis & Son is the factory of the American Card Clothing Company near Stetson's dam. Eight hands are employed at this factory and no polluting matter is discharged into the stream.

Stetson's Pond is the first place where the river is ponded below the points where the drainage is now or was formerly discharged from the cotton waste mill, the paper mill, the dye and chemical works and the wool-scouring establishment of E. F. Lewis. When the wool-scouring establishment was in operation much complaint was made of the offensive condition of the pond, but it is now said to be in much better condition than it was then. At the time it was visited in 1891 there was a thin film of oil upon its surface but no noticeable odor.

A small hat factory located at Stetson's dam has been vacated.

At Tilton Station, about a mile below Stetson's dam, is a mill privilege at present unused.

At East Walpole, a mile further down the stream, is the paper mill of F. W. Bird & Son, employing 118 hands, as against 60 in

1885. About 4,000 tons of stock are made into paper yearly. Of this, one-half is what is termed raw stock and consists of old rope, old bagging, tarred rope, a few rags and some ends from oiled carpeting. The other half consists of "papers," such as straw-board clippings, hardware papers, manila papers and newspapers. The materials used in the manufacturing processes are alum, quick-lime, chloride of lime, dyestuffs and soda-ash. About two-thirds of a ton of quick-lime and 350 pounds of chloride of lime are used daily. The dyestuffs consist of Venetian red, yellow ochre, oxide of iron, copperas, logwood extract and lamp black in liquid form. The total amount of all of them used daily is about 1,000 pounds.

All of the refuse from manufacturing, including the dirt washed from the stock and the waste dyestuffs, goes directly into the stream. The amount of dyestuff is often so great as to give the river a decided color for several miles down stream. The river water is used for washing the stock but for other manufacturing processes filtered water is used. Water from a spring near by is used in the boilers. Before the removal of Lewis' wool-scouring establishment filtered water was used for all processes as the river water was too dirty.

A short distance below Bird's mill is the paper mill of Hollingsworth & Vose. The pond above this mill had a very foul appearance when visited but the odor was not very strong at any time. Bubbles of gas, resulting from the decomposition of organic matter in the bottom of the pond, were continually rising, occasionally bringing with them masses of black mud having a green surface, which collected near the dam. Where the water flows over the dam there was a distinct and offensive odor. At this mill 65 hands are employed, which is three times the number employed in 1885. Manila papers are manufactured out of old rope, about 3,000 tons of stock being used per year. It is first cleaned by dusting and is subsequently washed. The principal materials used in working up the stock are chloride of lime, quick-lime and alum, together with very small amounts of soda-ash and flour or starch. About one ton of quick-lime and 800 pounds of chloride of lime are used daily, which is about three times the quantity used in 1885. River water is used for boiling in the bleachers and for the first wash. For all other purposes filtered water is used. Some of this

water is obtained from the large well near the river, but about one million gallons are obtained by filtering the river water through a mechanical filter, using alum as the coagulant. The matters intercepted by this filter, including the coagulant, are turned into the stream, as is all other refuse from the various manufacturing processes, except the dustings from the stock, which are said to be sold to farmers.

A short distance below this mill is an unused mill privilege also owned by Hollingsworth & Vose. At this dam an abundant growth of the fungus *Beggiatoa*, which has already been mentioned, was found clinging to submerged objects. This was the farthest point up stream at which it was noticed in abundance.

Norwood. — The river, after leaving Walpole, passes through the southerly portion of this town, and the natural drainage of the whole town goes into the river or its tributaries. The town is provided with a public water supply, but has no system of sewerage. There is, however, a ten-inch pipe sewer leading from a point near the centre of the town to the river, which conveys to it the water from several open ditches. One of these ditches brings to the sewer the drainage from the tannery owned by the Lyman Smith's Sons Company, and the others bring more or less sewage turned into them from buildings in the central part of the town.

A little more than half a mile below the lower dam of Hollingsworth & Vose a tributary, known as Hawes Brook, enters the river from the west. On this brook is located the tannery of Winslow Brothers, employing 175 hands, as against 125 in 1885. These numbers do not include the men employed at the finishing shops on the hill from which no refuse enters the stream.

Somewhat more than a million sheepskins and about one hundred thousand goat and calf skins are tanned and finished at this place annually. The sheepskins are about one-half foreign and one-half domestic, and by far the greater part of them come to the tannery either in lime or in pickle in about equal quantities, but some are received with the wool on, either green-salted or dry-cured. The pickled, or processed, skins when received at the tannery are ready for tanning without further preparation. The limed skins when received are prepared to the extent of pulling the wool only. The goatskins are nearly all foreign dry-cured skins and the calfskins

are mostly domestic green-salted. The total number of skins which are unhaired or from which the wool is pulled amounts to about a quarter of a million annually.

In the manufacturing processes the materials used yearly are approximately as follows: —

For Unhairing, Liming, Drenching and Processing.

Lime,	350 barrels.
Sodium sulphide,	25 tons.
Bran and flour,	50 tons.
Sulphuric acid,	30 tons.
Salt,	240 tons.

For Tanning.

Ground sumach,	300 tons.
Extract of hemlock bark,	100 tons.
Gambier,	100 tons.

The refuse from the manufacturing processes is discharged into a series of shallow settling basins formed by dikes, in which the greater part of the solid matter is intercepted. The effluent from the basins flows into the brook, which is very badly polluted at all points below, and has at times a very offensive odor.

The paper mill of Isaac Ellis, which was located upon the brook above the tannery in 1885, was burned in July, 1888, and has not been rebuilt.

The next establishment on the main river below Hawes Brook is the printing-ink works of George H. Morrill & Co. Twenty-one hands are now employed at this place, an increase of six since 1885. It is said that no manufacturing waste enters the stream at this place except a small amount of lamp black which, having escaped into the air and settled in different places around the works, is washed into the stream by rains. The bed and banks of the stream below the works, however, are coated with a tarry matter which is not found above them, and which probably comes from the portion of the works where gas is manufactured, to be subsequently used in making the lamp black. The operatives use a privy which discharges into the stream.

Near the Norwood Station on the New York & New England Railroad is located the tannery of Lyman Smith's Sons Company, employing an average of 175 hands throughout the year. In the

year ending July 1, 1891, 1,110,180 sheepskins were tanned at this place, of which rather more than one-half were pickled or processed skins. The company declined to furnish a list of the materials used in the manufacturing processes, but the methods are about the same as at the tannery of Winslow Brothers, except that hemlock bark is used instead of the extract, and only a very small amount of wool pulling is done. The drainage from the works flows into settling basins in which some of the solid matters are retained and afterwards cleaned out and carted away. From these basins the drainage overflows into a ditch and passes through the sewer already mentioned to the river, a little more than half a mile below the ink works. At the point where the drainage from the tannery enters the river there was a deposit of black matter, and a decidedly offensive odor was noticed in this vicinity.

The only other works of importance in Norwood are the New York & New England Railroad car shops. Dry privies are used at this place so that there is no noticeable pollution of the streams.

As already mentioned, the most polluted portion of the whole river is near the head of the Fowl Meadows, after the river has received the manufacturing drainage from all of the establishments in Walpole and Norwood. As the water first enters the meadows and the current becomes sluggish its condition is apparently a little worse than at any other point. In appearance it resembled a huge sink drain, and its odor was very offensive at all times. Passing through this portion of the stream in a boat, a mass of floating matter about three inches in thickness, similar to that seen in the Hollingsworth & Vose millpond, was encountered, which covered the surface of the river from bank to bank for a distance of more than one hundred feet. Bubbles frequently arose from the bottom of this portion of the stream, bringing with them at times small masses of the muddy deposit.

Sharon. — This town is provided with a public water supply, but has no sewerage system. There are no sewers or factories in the town which contribute any considerable amount of polluting matter to the streams.

Stoughton — This town is provided with a limited public water supply, but has no sewerage system. The streams in the town are small, and the amount of polluting matter turned into them is not large, and, as a whole, has not changed much since 1885.

Since then the small woollen mill of Consider Southworth, on Muddy Brook in West Stoughton, has been burned, and the small cotton-twine manufactory of A. Southworth, farther down the same stream, has been vacated.

French & Ward's woollen mill, which is also located on Muddy Brook, now employs from 175 to 200 hands, an increase of from 25 to 50 since 1885. From 300 to 400 pounds of wool, which shrinks from 25 to 40 per cent., are scoured here daily. All refuse from manufacturing goes directly into the stream.

Canton.—Nearly all of this town lies within the Neponset River basin. There is a public water supply, but no public sewerage system.

Since 1885 the number of sources of pollution has been reduced by the destruction by fire of the woollen yarn mill at Springdale and by the removal of the Canton Paint and Oil Company.

At two establishments the business has increased. The Eureka Silk Manufacturing Company, which has three mills just above the central portion of the village, employs 300 hands, who use privies emptying into the stream. This is double the number employed in 1885. All kinds of silk threads are made and dyed here, the product amounting to about 150,000 pounds per year. Logwood, iron and aniline colors are used in dyeing, and a large amount of soap is used for washing. All refuse from the manufacturing operations goes into the stream.

The Canton Manufacturing Company, located in the lower portion of the town and engaged in bleaching fine cotton goods, has now 50 employees, as against 22 in 1885. The chemicals used in bleaching are sulphuric acid, bleaching powder and soda-ash. About 82,000 pounds of acid and fifty casks each of bleaching powder and soda-ash are used per year. About five-eighths of a barrel of alum per day is used in the mechanical filter through which about one million gallons of water are filtered daily. All wastes, both from manufacturing processes and from the privies, go into the stream.

The other large factories upon the stream in this town are the works of the Kinsley Iron and Machine Company and the Revere Copper Company. At these establishments the conditions are about the same as in 1885, except that there has been a reduction of about 20 per cent. in the force employed at both places.

The other important source of pollution in the town is the woollen

mill of Draper Brothers at Canton Corners, where from 85 to 90 men are usually employed, but sometimes as many as 120. From 150,000 to 200,000 pounds of wool are scoured here yearly. The situation of this mill is peculiar in that it is not located upon a stream but derives its water supply from a well. All refuse from wool scouring and from dyeing flows on to swampy land near by, from which a stream starts which consists almost wholly of drainage from this mill. Further down the valley the drainage is diluted somewhat as the size of the stream is increased by surface and subterranean tributaries, but in all places down to the meadows the stream is extremely foul, and has a very offensive odor.

Dedham, Hyde Park, Milton and Dorchester. — All of these places are below the Fowl Meadows, and, as the conditions as regards the pollution of the river do not vary radically from those which existed in 1885, no detailed description of the sources of pollution will be given.

The principal sources of manufacturing pollution are the wool-scouring and paper mills. The amount of wool scouring in 1891 was about the same as in 1885; the quantity scoured at the Merchants' woollen mill in East Dedham being enough smaller at the latter date to offset the increase at the mills of Robert Bleakie & Co. and John Scott in Hyde Park.

In 1885 there were three paper mills on the main river, below Mother Brook, all owned by Tileston & Hollingsworth. The second of these mills was burned and has not been rebuilt, but the number of operatives employed and the yearly product of paper at the upper mill have been increased more than enough to make up for this loss.

Taking all of the mills and factories on the streams in these towns together there has been an increase of 16 per cent. in the number of operatives.

Above Mother Brook, in Hyde Park, the pollution of the river is noticeable to the eye, but the water does not have an offensive odor. In Mother Brook and at points further down the main river the water looks more polluted and smells badly at times. The lower part of the river receives considerable sewage matter both from privies and from sewers and drains. The water in the river above Mother Brook is satisfactory for use in boilers, but further down the stream causes more or less foaming in them.

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

At the end of 1891 the State contained 28 cities and 323 towns, no change having been made in the number of cities or towns since the previous year.

During 1891 a public water supply was introduced into the towns of Foxborough, Holliston, Leicester, Millis and Reading, so that at the end of the year all of the cities and 114 towns, a total of 142 places, were provided with a public water supply.

The following table gives a classification, by population, of cities and towns having and not having public water supplies Dec. 31, 1891. The populations are taken from the census of 1890: —

POPULATION (1890).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	28	9,772
500-1,000,	5	4,566	62	47,667
1,000-1,500,	4	4,948	44	54,105
1,500-2,000,	8	13,574	28	50,171
2,000-2,500,	9	19,987	14	30,299
2,500-3,000,	7	19,663	18	49,262
3,000-3,500,	8	26,010	5	15,899
3,500-4,000,	6	22,457	3	11,263
4,000-4,500,	11	47,201	5	21,367
4,500-5,000,	13	60,954	1	4,642
Above 5,000,	71	1,718,998	1	6,138
TOTALS,	142	1,938,358	209	300,585

From the totals given in the table it will be seen that, although but forty per cent. of the cities and towns in the State have a public water supply, yet the total population of places supplied represents 86.6 per cent. of the whole population of the State. In this estimate

of the total population of municipalities supplied all of the inhabitants in them are included, and it consequently includes rather more than the actual number of persons to whom a public water supply is available; the difference, however, is not large. There are now but 7 towns having a population exceeding 4,000 which are not provided with a public water supply. These are given in the following table:—

Towns.	Population in 1890.	Towns.	Population in 1890.
Blackstone,	6,138	Winchendon,	4,390
Provincetown,	4,642	Rockport,	4,087
Ipswich,	4,439	Barnstable,	4,023
Millbury,	4,428		

In the following table the various water supplies are classified according to the dates when a fairly complete system of supply was first introduced into a city or town:—

Years.	Number of Places Supplied.	Years.	Number of Places Supplied.
Previous to 1850,	6	1880–1889, inclusive,	68
1850–1859, inclusive,	4	1890,	5
1860–1869, inclusive,	10	1891,	5
1870–1879, inclusive,	44	Total,	142

Of the 28 cities in the Commonwealth, 24, having a total population in 1890 of 1,302,929, own their water works, while 4, having a total population of 69,371, are wholly supplied by private companies. Of the 114 towns having public water supplies, 64, with a total population of 350,577, are supplied from their own works, while 50, with a total population of 215,481, are supplied by private companies. The total population in both cities and towns owning their works is 1,653,506, against 284,852 in those supplied by private companies.

The following table gives statistics with regard to the consumption of water in many of the cities and towns in this State. The populations for 1891, as given in the table, were obtained in a somewhat

arbitrary manner by adding one-fifth of the increase in population from 1885 to 1890 to the population as determined by the census taken in the latter year. The daily consumption per inhabitant, obtained by dividing the average daily consumption by the total population of the city or town in 1891, shows a large variation, which, in most cases, is due to the different rate at which water is used in different places. In some cases, however, where the consumption per inhabitant is very low, it is occasioned by using the total population of the town as a divisor when only a limited portion of the inhabitants were supplied with water. This is especially the case where there are villages in the town to which the water works have not been extended, or where works have recently been built and there has not been sufficient time for the general introduction of water.

Statistics relating to the Consumption of Water in various Cities and Towns.

City or Town.	Population. 1891.	Average Daily Consumption. Gallons. 1891.	Daily Consumption per Inhabitant. Gallons.
Abington and Rockland, . . .	9,671	293,000	30
Andover, . . .	6,228	177,000	28
Beverly, . . .	11,148	765,000	69
Boston (Cochituate Works), . .	421,611	37,687,000	89
Boston, Somerville, Chelsea and Everett (Mystic W'ks),	121,137	9,055,000	75
Braintree, . .	5,010	299,000	60
Bridgewater and East Bridgewater,	7,264	102,000	14
Brockton, . .	28,596	669,000	23
Brookline, . .	12,685	980,000	77
Cambridge, . .	72,102	4,871,000	68
Cohasset, . . .	2,494	55,400	22
Danvers and Middleton, . . .	8,461	513,000	61
Dedham, . . .	7,219	212,000	29
Easton,* . . .	4,602	85,500	19
Fall River, . .	77,904	2,356,000	30
Framingham,* .	9,432	221,000	23
Franklin, . . .	5,001	111,000	22
Gardner, . . .	8,652	439,000	51
Gloucester, . .	25,241	491,000	19
Hyde Park and Milton, . . .	14,979	498,000	33
Lawrence, . .	45,812	3,180,000	69
Lowell, . . .	80,414	5,920,000	74
Lynn and Saugus, .	61,536	3,131,000	51
Mansfield, . .	3,531	162,000	46
Marblehead, . .	8,339	155,000	19
Marlborough, .	14,378	364,000	25
Middleborough, .	6,245	149,000	24
Montague, . .	6,429	312,000	49
Nantucket, . .	3,293	65,200	20
Natick, . . .	9,250	317,000	34
New Bedford, .	42,201	4,146,000	98
Newburyport, .	13,993	423,000	30
Newton, . . .	25,303	1,067,000	42
No. Attleborough, .	6,800	168,000	25
Norwood, . .	3,895	178,000	46
Randolph and Holbrook, . . .	6,476	274,000	42
Revere and Winthrop, . . .	9,071	473,000	52
Salem, . . .	31,343	2,726,000	87
Sharon, . . .	1,695	30,000	18
Swampscott and Nahant, . .	4,272	285,000	67
Taunton, . .	25,803	1,022,000	39
Waltham, . .	19,527	769,000	39
Ware, . . .	7,594	196,000	26
Watertown and Belmont, . . .	9,430	333,000	35
Wellesley, . .	3,717	253,000	68
Weymouth, . .	10,891	185,000	17
Whitman, . .	4,610	123,000	27
Woburn, . .	13,849	731,000	53

* The population given is that of the whole town but only a part of the town is supplied with water.

Rainfall.

The rainfall for the whole year 1891 was somewhat above the average, but it was very unevenly distributed. In the first three months it was excessive, and during the remainder of the year was below the normal. During these drier months the deficiency in rainfall produced a drought, which, though not as severe as droughts which have occurred in previous years, was long-continued, and in many cases caused a heavy draught upon ponds and reservoirs used as sources of water supply, thereby reducing their level to a lower point than for several years.

The average annual rainfall * in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.22 inches. In the following table is given, in inches, the normal rainfall for each month in the year, the rainfall for each month in 1891, and the departures from the normal. †

	Normal Rainfall. Inches.	Rainfall 1891. Inches.	Excess or Deficiency. Inches.		Normal Rainfall. Inches.	Rainfall 1891. Inches.	Excess or Deficiency. Inches.
1891.				**1891.**			
January,	4.01	7.35	+3.34	July,	3.93	4.02	+0.09
February,	3.67	5.02	+1.35	August,	4.32	3.66	−0.66
March,	4.10	4.63	+0.53	September,	3.40	2.28	−1.12
April,	3.40	2.92	−0.48	October,	3.96	4.63	+0.67
May,	3.56	2.08	−1.48	November,	3.98	2.74	−1.24
June,	3.30	3.55	+0.25	December,	3.59	4.02	+0.43

* Including melted snow.

† This and subsequent tables of rainfall have been prepared from the records of the New England Meteorological Society.

To enable the condition preceding the collection of samples of water in any part of the State to be understood, the following tables are presented, which give the daily rainfall in inches at nine stations scattered about the State : —

Daily Rainfall at Nine Places in Massachusetts, Geographically selected.

January, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.02	-	0.14	*	*	-	-	-	-
2, . .	0.65	0.65	0.41	*	*	-	1.14	1.92	1.64
3, . .	0.30	-	0.02	1.35	1.55	0.98	0.11	0.19	0.14
4, . .	-	-	-	*	-	-	-	-	-
5, . .	0.05	0.08	0.14	0.10	0.35	0.21	*	0.40	0.36
6, . .	-	-	-	-	-	-	0.43	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.70	0.55	1.02	*	*	-	0.51	0.58	0.74
12, . .	1.30	0.60	0.68	1.18	1.06	1.07	0.26	0.40	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	0.10	-	0.06	0.03	0.03	0.07	0.01	0.10	0.12
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	0.75	*	0.98	*	*	-	0.78	*	*
18, . .	0.75	*	0.21	1.93	1.72	1.36	0.78	2.35	3.58
19, . .	0.05	1.41	-	-	-	-	0.05	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	0.05	0.03	-	*	-	-	-	-	-
22, . .	1.50	1.13	1.44	1.09	1.09	1.01	0.90	1.10	0.73
23, . .	-	0.03	-	-	-	-	-	-	-
24, . .	-	-	-	*	-	-	-	-	-
25, . .	1.00	1.15	1.48	0.91	0.76	1.02	0.85	0.90	-
26, . .	-	-	-	-	-	-	-	-	0.81
27, . .	0.05	-	0.03	0.04	-	0.01	0.02	0.07	0.05
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.30	0.30	0.25	*	0.37	-	0.31	0.33	0.38
30, . .	0.20	-	0.17	0.39	-	0.38	-	-	-
31, . .	0.10	0.60	0.03	0.34	0.05	-	0.06	-	0.62
Totals,	7.87	6.53	7.06	7.36	6.98	6.11	6.21	8.34	9.17

February, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.25	-	0.37	0.34	0.29	0.47	0.36	0.57	0.05
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.30	0.40	0.22	0.51	0.52	0.36	0.52	0.57	0.49
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	0.05	-	0.04	0.14	0.20	0.13	0.19	0.24	0.21
7, . .	0.05	-	0.48	*	*	-	0.49	-	*
8, . .	0.35	*	0.62	0.68	0.78	0.44	-	0.51	0.43
9, . .	0.10	*	0.38	*	*	-	*	*	*
10, . .	0.65	1.05	0.38	0.74	0.80	0.71	0.81	0.62	0.62
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	0.15	*	0.02	0.08	0.35	0.03	-	0.17	*
17, . .	0.75	*	0.29	0.12	0.24	-	*	0.40	*
18, . .	0.35	0.43	0.13	0.50	-	0.41	0.51	0.21	1.03
19, . .	-	-	-	-	-	-	-	-	-
20, . .	0.40	*	0.45	*	*	-	*	0.25	0.53
21, . .	0.30	*	0.23	*	*	-	0.79	0.32	*
22, . .	0.20	0.70	0.02	0.71	0.79	0.72	0.09	0.21	0.64
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	0.10	*	0.05	*	*	0.02	*	0.04	*
26, . .	0.30	*	0.42	*	*	-	0.67	1.22	*
27, . .	0.40	0.72	0.41	1.22	1.20	1.15	0.47	0.34	1.45
28,	-	-	0.05	0.08	0.12	0.11	*		0.33
Totals,	4.70	3.30	4.56	5.12	5.29	4.55	4.90	5.67	5.78

* Precipitation included in that of following day.

Daily Rainfall at Nine Places in Massachusetts, Geographically selected — Continued.

March, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	0.11	0.25	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.02	-	*	*	*	-	-	0.01	-
4, . .	0.40	*	*	2.05	1.77	-	1.03	-	1.03
5, . .	0.10	1.13	1.69	-	-	1.44	0.65	†1.10	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	0.52	0.40	0.21	1.38	*	-	*	0.26	0.87
10, . .	1.00	1.16	1.01	-	0.77	1.33	0.73	0.67	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.15	0.07	0.15	*	*	-	*	0.13	*
13, . .	0.30	0.33	0.61	0.87	0.83	0.84	*	1.49	2.08
14, . .	0.15	0.14	-	-	-	-	0.84	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	0.01
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.05	-	0.01	0.16	0.08	0.04	0.06	-	-
20, . .	-	-	-	-	*	-	0.01	-	-
21, . .	0.05	-	0.51	*	*	-	1.20	*	*
22, . .	0.20	0.03	0.92	*	2.18	-	0.12	1.93	1.61
23, . .	0.05	0.44	0.06	*	-	-	0.17	-	-
24, . .	-	-	-	2.17	-	1.45	-	0.02	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	0.01
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	2.99	3.70	5.17	6.63	5.63	5.10	4.92	5.86	5.61

April, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	*	-	-	-	*
3, . .	1.20	1.20	2.44	2.48	*	1.60	1.48	1.50	1.32
4, . .	-	-	-	-	1.83	-	-	0.51	0.02
5, . .	-	-	-	-	-	-	-	0.01	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.25	-	0.20	*	*	-	*	0.10	*
12, . .	0.60	0.97	0.54	0.44	0.33	0.30	0.18	0.56	0.49
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	0.40	0.55	0.71	0.58	0.58	0.39	0.43	0.48	0.23
16, . .	-	-	0.02	-	-	0.12	-	0.01	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	0.30	-	0.32	*	*	0.81	*	-	0.02
19, . .	-	0.21	-	0.14	0.15	-	0.09	0.53	0.51
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	0.05	-	-	-	-	-	-	-	0.04
23, . .	0.05	-	-	-	-	0.01	-	0.13	0.17
24, . .	-	-	-	-	-	-	-	-	-
25, . .	0.02	-	0.03	0.12	0.09	-	-	0.14	0.09
26, . .	-	-	-	-	-	0.05	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
Totals,	2.87	2.93	4.26	3.76	2.98	3.28	2.18	3.97	2.89

* Precipitation included in that of following day.

† Average of rainfall at Plymouth and Providence. No record of rainfall at Taunton for this day.

Daily Rainfall at Nine Places in Massachusetts, Geographically selected — Continued.

May, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.35	0.51	0.24	0.10	0.10	0.23	0.14	0.29	0.21
4, . .	-	-	-	-	-	-	-	0.01	0.02
5, . .	-	-	-	-	-	-	-	-	-
6, . .	0.02	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.05	0.17	-	0.09	-	0.10	-	0.19	0.02
13, . .	-	-	-	-	-	0.17	0.09	0.07	0.04
14, . .	-	-	-	-	-	-	-	-	-
15, . .	*	-	-	-	*	-	-	-	-
16, . .	0.45	0.72	0.71	1.21	*	-	0.37	1.70	0.57
17, . .	0.10	0.08	0.11	-	1.43	1.35	0.45	0.10	0.90
18, . .	-	-	-	-	-	-	-	0.05	0.01
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	0.01	0.06	-	0.17	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	0.03	0.54	0.02	0.14	0.10	0.09	0.11	0.05	0.10
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.50	0.66	0.66	*	0.42	-	0.51	0.03	*
30, . .	0.05	-	0.04	0.57	-	0.37	-	0.03	0.35
31, . .	-	-	-	-	-	-	-	0.04	-
Totals,	1.55	2.68	1.79	2.17	2.05	2.48	1.67	2.56	2.22

June, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	1.10	1.42	0.07	0.40	0.46	0.28	*	-	0.02
3, . .	0.10	0.03	0.01	-	*	-	0.19	-	-
4, . .	0.65	0.96	0.91	0.35	0.42	0.83	0.43	0.32	0.09
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	0.05	-	-	-	-	-	-	-	-
17, . .	-	-	0.15	*	*	-	-	-	-
18, . .	0.88	1.15	0.83	*	*	-	*	0.76	*
19, . .	0.10	0.13	0.04	*	*	-	1.21	0.03	0.73
20, . .	0.10	0.07	-	1.12	1.15	-	0.08	0.20	0.13
21, . .	0.10	-	0.01	*	*	0.57	-	-	-
22, . .	0.75	1.17	1.23	1.47	1.75	-	2.05	0.70	0.52
23, . .	-	-	0.01	-	-	1.61	-	-	0.10
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	0.21	-	0.23	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	0.01	-	0.03	0.01	0.03	0.02	0.04
30, . .	-	-	-	0.03	-	-	0.01	-	-
Totals,	3.83	4.93	3.48	3.37	4.04	3.30	4.00	2.03	1.63

* Precipitation included in that of following day.

Daily Rainfall at Nine Places in Massachusetts, Geographically selected — Continued.

July, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	0.01
3, . .	-	-	-	-	-	-	-	-	-
4, . .	0.25	0.30	0.22	0.19	0.20	0.18	0.26	0.23	0.26
5, . .	0.02	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	0.30	0.31	0.61	*	*	-	*	0.21	*
8, . .	0.75	0.98	0.35	0.70	0.56	1.11	0.73	0.60	0.63
9, . .	-	-	-	-	-	-	-	0.23	0.44
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	0.01	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	0.20	0.16	0.14	0.04	0.07	0.06	-	0.02	-
16, . .	-	0.02	-	-	-	-	0.03	0.17	0.47
17, . .	-	-	-	-	-	-	-	-	-
18, . .	1.00	0.63	0.64	*	*	-	*	0.07	*
19, . .	0.52	0.50	0.10	0.26	0.30	0.34	0.22	-	0.04
20, . .	-	0.16	-	-	-	-	-	-	0.03
21, . .	-	-	-	-	-	-	-	-	0.01
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	0.50	0.54	0.46	0.57	0.71	0.39	0.29	0.70	0.17
25, . .	0.25	0.44	-	-	-	-	0.02	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	0.10	-	-	*	*	-	-	-	-
29, . .	1.00	0.46	0.78	0.79	0.75	0.47	0.71	0.07	0.02
30, . .	0.20	0.16	0.09	-	*	-	-	0.02	-
31, . .	0.75	0.56	0.56	0.52	0.85	0.63	0.74	0.13	0.09
Totals,	5.84	5.22	3.95	3.07	3.44	3.20	3.00	2.46	2.17

August, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	*	-	*	-	-
2, . .	-	-	0.06	0.24	0.16	0.06	0.03	0.03	0.30
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	0.02	0.15	0.03	*	-	-	-	-	-
6, . .	0.10	0.07	0.03	0.48	0.38	0.03	0.08	0.01	0.02
7, . .	-	-	0.02	0.11	0.26	0.29	0.13	0.03	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	0.03	0.03
11, . .	-	-	-	-	-	-	-	0.60	-
12, . .	0.05	0.93	0.05	0.72	0.32	-	0.01	0.37	0.09
13, . .	-	-	-	-	-	-	-	0.03	-
14, . .	-	-	-	-	-	-	-	0.02	0.02
15, . .	0.65	0.53	0.90	0.74	*	-	0.48	0.61	0.46
16, . .	-	-	-	-	0.60	0.28	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	0.15	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	*	-	-	-	-
22, . .	1.05	1.12	0.34	0.73	0.63	0.34	0.43	0.10	0.03
23, . .	0.40	-	-	0.19	-	-	-	-	*
24, . .	-	0.31	0.16	-	-	0.03	-	0.02	0.03
25, . .	-	0.03	0.03	-	-	-	-	-	-
26, . .	0.05	0.04	0.01	-	-	-	-	-	*
27, . .	0.25	0.15	0.26	*	*	-	-	0.45	*
28, . .	0.40	0.17	0.51	1.69	1.17	0.31	1.30	1.02	0.35
29, . .	-	-	-	-	-	0.61	-	-	*
30, . .	0.15	0.15	0.05	*	*	0.06	0.21	*	*
31, . .	0.05	-	0.03	0.32	0.50	-	0.08	0.06	0.34
Totals,	3.32	3.65	2.48	5.22	4.02	2.01	2.75	3.38	2.17

* Precipitation included in that of following day.

Daily Rainfall at Nine Places in Massachusetts, Geographically selected — Continued.

September, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.05	0.07	0.07	-	0.02	0.04	0.15	0.12	0.01
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	0.35	-	0.18	*	*	-	0.12	0.77	*
6, . .	0.40	0.04	0.24	1.87	*	-	0.17	0.18	*
7, . .	0.25	0.57	0.86	-	2.83	0.91	1.56	1.02	1.53
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	0.25	-	0.05	*	*	-	*	-	-
14, . .	-	0.30	0.02	0.27	0.10	0.34	0.20	0.19	0.26
15, . .	-	-	-	*	-	0.03	-	0.02	*
16, . .	-	0.08	-	0.11	-	-	0.02	-	0.10
17, . .	0.02	-	-	-	-	0.15	*	-	-
18, . .	-	-	-	-	-	-	0.04	-	-
19, . .	0.10	-	0.14	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	0.03
29, . .	0.35	0.30	0.31	0.10	0.12	-	*	-	0.04
30, . .	-	-	-	-	-	-	0.05	0.10	-
Totals,	1.77	1.31	1.87	2.35	3.07	1.47	2.31	2.40	1.97

October, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-		-
2, . .	-	-	-	-	-	-	-		-
3, . .	-	-	-	-	-	-	-		-
4, . .	-	-	-	-	-	-	-		0.01
5, . .	-	-	0.01	0.14	0.07	-	0.23		0.41
6, . .	-	-	-	-	-	-	-		-
7, . .	0.05	-	0.24	0.02	*	-	*		0.02
8, . .	0.70	0.70	0.94	1.51	2.45	1.00	1.77		2.12
9, . .	-	-	-	-	-	-	-		-
10, . .	-	-	-	-	-	-	-		-
11, . .	-	-	0.04	0.08	0.02	0.08	-		0.02
12, . .	-	-	-	-	-	-	-		-
13, . .	1.00	1.01	1.05	*	*	-	*		*
14, . .	0.50	0.71	0.16	0.55	1.83	0.66	1.93		1.67
15, . .	-	-	0.01	0.02	0.04	-	0.08		0.13
16, . .	-	-	-	-	-	-	-	No record.	-
17, . .	-	-	-	-	-	-	-		-
18, . .	-	-	-	-	-	-	-		-
19, . .	-	-	-	-	-	-	-		-
20, . .	1.30	1.10	1.20	0.70	1.04	0.84	0.68		0.74
21, . .	-	-	-	-	-	-	-		-
22, . .	*	-	-	-	*	-	-		*
23, . .	0.03	0.15	0.04	0.58	0.62	0.06	0.63		0.82
24, . .	-	-	-	-	-	-	-		-
25, . .	-	-	-	-	-	-	-		-
26, . .	0.05	-	-	*	-	-	*		0.01
27, . .	0.10	0.15	0.04	0.10	0.13	0.32	0.18		0.46
28, . .	-	-	-	-	-	-	-		-
29, . .	-	-	-	-	-	-	-		-
30, . .	-	-	-	-	-	-	-		-
31, . .	-	-	-	-	-	-	-		-
Totals,	3.73	3.82	3.73	3.70	5.70	2.96	5.45	5.48	6.41

* Precipitation included in that of following day.

Daily Rainfall at Nine Places in Massachusetts, Geographically selected — Concluded.

November, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	0.02	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	*	-	*
6, . .	-	-	-	-	-	-	0.05	0.06	0.17
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	0.01	-
10, . .	-	-	-	*	-	-	-	0.02	*
11, . .	0.50	0.33	0.44	0.32	0.32	0.26	*	0.16	0.11
12, . .	-	0.03	-	-	-	-	0.24	0.01	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	0.10	-	0.08	*	*	-	-	*	*
17, . .	1.15	0.10	0.64	0.78	*	0.40	0.21	1.15	0.56
18, . .	-	0.15	-	-	0.93	-	0.21	-	0.23
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.20	*	0.57	0.52	0.23	0.40	-	*	*
24, . .	0.35	0.55	0.17	-	-	-	-	0.19	0.33
25, . .	-	-	-	-	-	-	-	-	-
26, . .	0.20	-	0.06	*	*	-	*	0.05	*
27, . .	0.40	1.00	0.94	1.38	1.19	1.20	1.21	1.83	1.62
28, . .	0.10	0.15	0.05	0.04	0.03	0.03	0.01	0.04	0.05
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
Totals,	3.00	2.31	2.97	3.04	2.70	2.29	1.93	3.02	3.07

December, 1891.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	0.20	0.45	0.64	0.52	0.36	-	*	*	0.20
5, . .	0.60	0.55	0.14	-	-	0.41	0.24	0.33	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	0.25	0.27	0.14	0.43	0.40	0.14	0.30	0.85	0.84
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	0.20	0.16	0.41	*	*	-	*	0.05	*
16, . .	0.40	0.38	0.13	0.51	0.52	0.61	0.79	0.05	0.22
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	0.15	0.11	*	-	-	-	*	-	*
23, . .	0.65	0.67	0.30	0.42	0.31	0.44	0.25	0.47	0.21
24, . .	0.60	0.75	0.61	*	*	0.08	0.16	0.56	*
25, . .	0.10	0.03	0.13	0.67	0.65	0.33	0.36	0.03	0.98
26, . .	0.50	0.43	0.40	0.31	0.28	0.27	*	0.23	*
27, . .	0.10	0.11	-	-	-	-	0.26	0.07	0.27
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.10	-	0.04	*	*	-	*	-	0.99
30, . .	1.00	1.53	1.32	0.90	1.21	0.95	1.22	0.98	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	4.85	5.44	4.26	3.76	3.73	3.23	3.58	3.62	3.71
Total for the Year, ...	46.3	45.8	45.6	49.5	49.6	40.0	42.9	48.8	46.8

* Precipitation included in that of following day.

Flow of Streams.

The total flow of the streams in 1891 was in excess of the normal yearly flow, but the seasonal distribution was very uneven, being excessive in the first four months of the year and less than the normal in all of the other months. This is shown by the following table, in which a comparison is made between the flow of the Sudbury River during each month in 1891 and the normal flow of the same river for each month, as deduced from thirteen years' observations, from 1879 to 1891 inclusive: —

Table showing the Average Monthly Flow of Sudbury River for the Year 1891 in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.

MONTH.	Normal Flow. Cubic Feet per Second per Square Mile.	Actual Flow in 1891. Cubic Feet per Second per Square Mile.	Excess or Deficiency. Cubic Feet per Second per Square Mile.
January,	2.166	4.669	+2.503
February,	3.415	5.393	+1.978
March,	4.179	6.890	+2.711
April,	3.047	3.709	+0.662
May,	1.593	0.901	—0.692
June,	0.747	0.640	—0.107
July,	0.277	0.231	—0.046
August,	0.441	0.252	—0.189
September,	0.458	0.314	—0.144
October,	0.870	0.325	—0.545
November,	1.171	0.471	—0.700
December,	1.488	0.842	—0.646
Average for the whole year,	1.645	2.034	+0.389

The next table shows the weekly fluctuations during 1891 in the flow of two streams, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts: —

Table showing the Average Weekly Flow of the Sudbury and Merrimack Rivers, in Cubic Feet per Second per Square Mile of Drainage Area, for the Year 1891.

Week ending Sunday.	Sudbury River. Cubic Feet per Second per Square Mile.	Merrimack River. Cubic Feet per Second per Square Mile.	Week ending Sunday.	Sudbury River. Cubic Feet per Second per Square Mile.	Merrimack River. Cubic Feet per Second per Square Mile.
Jan. 4,	1.686	2.473	July 5,	0.243	0.685
11,	2.197	2.091	12,	0.249	0.767
18,	5.905	3.820	19,	0.155	0.564
25,	7.902	4.428	26,	0.199	0.712
Feb. 1,	4.301	4.522	Aug. 2,	0.312	0.599
8,	4.854	3.188	9,	0.198	0.509
15,	3.103	2.402	16,	0.209	0.406
22,	6.585	2.905	23,	0.233	0.450
Mar. 1,	6.632	4.916	30,	0.353	0.713
8,	4.742	3.589	Sept. 6,	0.351	0.778
15,	11.024	5.812	13,	0.598	0.664
22,	6.589	5.069	20,	0.232	0.509
29,	6.515	8.397	27,	0.180	0.451
Apr. 5,	5.572	5.584	Oct. 4,	0.138	0.415
12,	4.519	4.253	11,	0.287	0.418
19,	3.850	6.999	18,	0.245	0.453
26,	2.159	5.336	25,	0.465	0.479
May 3,	1.405	2.629	Nov. 1,	0.352	0.458
10,	0.941	1.986	8,	0.252	0.392
17,	0.899	1.633	15,	0.300	0.396
24,	0.916	1.836	22,	0.458	0.532
31,	0.682	1.199	29,	0.881	0.832
June 7,	0.742	1.412	Dec. 6,	0.735	0.641
14,	0.395	0.969	13,	0.840	0.979
21,	0.486	0.746	20,	0.513	0.561
28,	1.097	1.159	27,	0.950	0.868

Occasional measurements of the flow of other streams have been made, and the results may be found on previous pages, as follows: Blackstone River, page 277; North Branch of Nashua River, pages 307 and 308; South Branch of Nashua River, page 309; Neponset River, page 322.

EXAMINATION OF SPRING WATERS.

EXAMINATION OF SPRING WATERS.

There is a large quantity of spring water sold throughout the State, particularly in cities and towns where the regular water supply is thought to be unsatisfactory, or where the water, as is not infrequently the case with surface-water supplies in the summer time, has an unpleasant taste and odor.

A considerable number of these spring waters were collected for examination during the summer of 1891, and at the same time a careful inspection of the surroundings of the springs was made, to discover possible sources of pollution. Not only is there a large sale of spring waters as such, but there is also a large amount consumed in bottled form, as soda water and other effervescing drinks.

As the result of this investigation, it was found that some of the springs were situated in regions nearly or quite free from population, where the land was not under cultivation, and the chemical examinations of these waters showed them to be of the highest purity. Other springs were situated in populous districts, or had near them direct sources of pollution, and the water gave evidence, on chemical analysis, that it had, in its course, received a large amount of drainage from sinks, cesspools, privies or stables. In most of the springs of this character which were examined the water showed, however, a high degree of purification by filtration through the ground.

The results of the chemical and bacteriological examinations are given below. In accordance with the system of classifying waters adopted in the Report on the Water Supplies of the State (see Special Report on the Examination of Water Supplies, 1890, pages 679 to 716), these spring waters have been divided into three groups, based on their chlorine contents.

The first group includes the normal waters and those in which the chlorine is not over 0.20 parts per 100,000 in excess of the normal; the second, those in which the excess of the chlorine is from 0.21 to

0.60 parts; the third group, those in which the excess of chlorine is over 0.60 parts. The first group contains the springs deriving their supply from water-sheds with little or no population; the second group, those in a moderately populated area; and the third includes the springs which are located in regions with considerable population.

Normal waters have been defined to be those which have not received any waste products of human life. They are as a rule confined to the water-sheds without population. Any excess of chlorine above the normal of the region in which the water is found is a measure of the amount of waste products, human and animal, that the water has taken up. But the evidence of contamination based on the chlorine alone does not tell us whether the source of pollution is near by or remote. This information is obtained from the determination of the nitrogen, which in freshly polluted water is present in the form of organic matter (albuminoid ammonia) and free ammonia, while in water which has percolated under favorable conditions through porous ground the nitrogen is all oxidized and appears in the form of nitrates.

In interpreting the analyses of the waters in the following classification, it is necessary to take into consideration the *degree* of purification which has taken place in those waters which are shown by their chlorine contents to have been at some time more or less contaminated. It is easily possible for a spring water which has somewhere in its course received a large amount of polluted drainage to be organically much purer than another in which the amount of contamination has been much less. The purifying power of porous ground, in which organic matter is exposed to bacterial action with access of air, is sufficiently great, under favorable conditions, to convert completely organic into mineral matter, as far as chemical analysis can indicate. It will be seen in the accompanying analyses that some of the waters which have received a large amount of pollution, and which may be said to be to a considerable extent filtered sewage, have less organic matter remaining in them, as shown by the albuminoid ammonia, than others in which the degree of contamination was originally much less.

In the process of filtration through porous ground, whereby organic matter in water is oxidized, there may also be effected a purification as regards disease germs. This latter and most important purification may be due to the removal of the germs by the

mechanical straining of the water at an extremely slow rate through the ground, or to the death of the germs, owing to unfavorable conditions for their life in the filtering process. While we cannot always know in any particular case which of these processes may have been the principal factor in the purification of the water, we know that the conditions of perfect mechanical filtration (whereby all suspended matters are removed from the water), and the conditions of perfect chemical purification, are those also most favorable for the complete removal of bacteria.

Although water badly contaminated with sewage or the wastes of human life may be purified by thorough filtration so as to be free from organic matter and from bacteria, yet in cases of ground waters of this origin and character we seldom feel complete security that the conditions of perfect filtration will always exist. A long-continued rainfall, for instance, may result in more rapid filtration and consequently less perfect purification; or the creation of new sources of contamination, nearer the spring, may result in its dangerous pollution.

It is for such reasons that a certain suspicion always attaches to ground waters which have at any time in their history been seriously polluted. The use of ground waters, whether springs or wells, in built-up communities, should therefore be avoided, for we have no control over the conditions of filtration, and have no means of knowing (except by constant vigilance in the examination of the water) when a water hitherto well purified may become injuriously impure. The danger from the use of ground waters in populous regions increases with the increase of population, and with the nearness of the sources of pollution to the spring or well.

No attempt was made to determine the species of bacteria in these spring waters, and the numbers of bacteria given in the tables are not, therefore, to be interpreted as expressing in any sense the relative fitness of the waters for drinking. In open wells, for instance, we may often find a large number of harmless bacteria which have come from the air or from dust, and which would not be found in the water if better protected. A favorable construction is, of course, to be put on the low numbers of bacteria, since they show that few bacteria of any kind are present, and that the conditions under which the water is filtered in the ground are favorable to its purification.

Normal Spring Waters, and those in which the Chlorine is not more than 0.20 Parts per 100,000 in Excess of the Normal.

Number.	Town.	Name of Spring.	Residue on Evaporation.	Ammonia.		Excess of Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
7439	Arlington, . .	Robbins, ...	6.60	.0000	.0000	.00	.1250	.0000	.0110	1.69	26
7396	Belmont, . .	Belmont Natural Mineral.	9.00	.0000	.0000	.00	.0085	.0000	.0140	4.57	18
7436	Boston, . .	Allandale Mineral, .	5.30	.0000	.0022	.00	.0350	.0000	-	1.82	1,728
9184	Framingham, .	Nobscot Mountain, .	3.55	.0004	.0000	.00	.0000	.0000	-	1.80	-
7492	Holbrook, . .	White Rock, . .	3.90	.0000	.0084	.00	.0070	.0000	.4310	0.79	171
6331	Lawrence, . .	Cold, ...	-	.0040	.0006	.00	.0010	.0000	.0000	-	-
6633	Lowell, . .	Sheeprock, . .	2.50	.0002	.0010	.00	.0070	.0000	.0200	0.32	5
7401	Medford, . .	Fulton Natural, .	4.40	.0000	.0000	.00	.0140	.0000	.0270	0.79	18
7395	Medford, . .	Middlesex Mountain,	6.30	.0000	.0018	.00	.0090	.0000	.0540	2.60	1,960
6519	Methuen, . .	Otis, ...	-	.0004	.0030	.00	.0070	.0000	.0100	-	2
7455	Milton, . .	Blue Hill Silver, .	2.30	.0002	.0002	.00	.0030	.0000	.0140	0.48	146
7406	Lynn, . . .	Echo Grove Mineral,	6.25	.0004	.0024	.01	.0000	.0000	-	3.12	9
7397	Chelsea, . .	Mount Washington, .	10.80	.0000	.0000	.05	.0500	.0000	.0100	4.29	50
7434	Stoneham, . .	Cedar Park Mineral,	4.90	.0000	.0012	.06	.0600	.0000	.0120	1.56	6
7484	Lowell, . .	Mount Pleasant, .	4.40	.0000	.0004	.07	.0300	.0000	.0130	0.95	56
7471	Brockton, . .	Indian, ...	3.00	.0000	.0000	.08	.0220	.0000	.0150	0.63	8
7415	Lynn, . . .	Electric, . . .	4.05	.0000	.0002	.09	.0400	.0000	.0110	0.95	5
7544	W. Springfield, .	Massasoit, . .	5.50	.0000	.0000	.09	.0600	.0001	.0160	2.86	-
7488	Stoughton, . .	Crystal, . . .	3.00	.0000	.0004	.14	.0300	.0001	.0030	0.95	24
7491	Whitman, . .	Goulding's, . .	3.90	.0000	.0000	.16	.1100	.0000	.0080	1.11	15
7472	Brockton, . .	Brockton Mineral, .	3.80	.0000	.0006	.17	.0120	.0000	.0190	1.43	973
7481	South Easton, .	Simpson's, . .	3.70	.0000	.0008	.17	.0500	.0000	.0130	1.27	1
7465	West Abington,	Highland, . . .	5.60	.0000	.0020	.20	.0800	.0000	.0100	1.27	1

Spring Waters in which the Excess of Chlorine above the Normal is from 0.21 to 0.60 Parts per 100,000.

Number.	Town.	Name of Spring.	Residue on Evaporation.	Ammonia.		Excess of Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
7441	Allston, . .	Harvard Crystal, .	11.20	.0002	.0012	.21	.3500	.0000	.0190	4.57	161
7442	Brighton, . .	Undine, . . .	5.60	.0002	.0014	.21	.2500	.0000	.0230	2.99	259
6582	Methuen, . .	Crystal, . . .	-	.0000	.0012	.24	.1700	.0000	.0000	-	24
7466	Brockton, . .	Granite Rock, . .	8.00	.0000	.0026	.39	.2000	.0000	.0190	1.95	2
6614	Lowell, . .	Hygeia, . . .	-	.0018	.0010	.39	.2500	.0000	.0100	-	12
7548	Springfield, .	Ingersoll Grove, .	8.70	.0000	.0008	.43	.5000	.0002	.0275	2.73	-
6517	Methuen, . .	Burnham, . . .	-	.0000	.0012	.44	.1900	.0000	.0000	-	2
6580	Lawrence, . .	Stevens, . . .	-	.0002	.0044	.44	.2600	.0000	.0000	-	2
6612	Dracut, . .	Thisselsia Mineral, .	11.70	.0028	.0024	.44	.1600	.0000	.0100	5.57	90
6516	Lawrence, . .	Knowles Diamond, .	-	.0002	.0016	.52	.4100	.0000	.0000	-	6
7416	Lynn, . . .	Lovers' Leap, . .	8.55	.0000	.0004	.57	.3250	.0000	.0220	3.25	9

Spring Waters in which the Excess of Chlorine above the Normal is over 0.60 Parts per 100,000.

Number.	Town.	Name of Spring.	Residue on Evaporation.	Ammonia.		Excess of Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
7435	Stoneham, . .	Chapman's Cr. Min.,	10.70	.0000	.0012	.61	.4500	.0000	.0090	2.86	15
7402	Lexington, . .	Commonwealth Min.,	11.90	.0000	.0000	.61	.4200	.0000	.0130	3.90	2
6632	Lowell, . .	Leland Mineral, .	12.90	.0008	.0032	.64	.3300	.0000	.0300	4.86	40
7467	Brockton, . .	Union, . . .	9.00	.0000	.0000	.75	.4500	.0001	.0150	2.73	18
7469	Brockton, . .	Crystal, . . .	10.20	.0000	.0010	.88	.4000	.0000	.0270	2.86	35
7394	Everett, . .	Partridge, . . .	20.35	.0000	.0000	1.51	.9000	.0000	.0240	6.00	59
7393	Everett, . .	Everett Crystal, .	20.25	.0000	.0018	1.57	1.0000	.0000	.0320	6.43	446
7420	Swampscott, .	Swampscott Mineral,	23.00	.0002	.0032	1.65	.7200	.0003	.0210	8.00	81
7392	Everett, . .	Belmont Hill, . .	23.55	.0000	.0008	2.18	1.1500	.0001	.0250	8.86	85
7391	Everett, . .	Glendale, . . .	16.30	.0000	.0006	2.28	.4000	.0000	.0230	5.71	35
7419	Swampscott, .	Moose Hill, . .	24.90	.0002	.0008	2.65	.7000	.0001	.0270	9.43	20

Description of the Springs and their Surroundings.

Arlington, Robbins Spring. — About two thousand feet south from the corner of Brattle and Main streets. Stoned and cemented reservoir, five feet wide and six feet deep, covered by a small house. The water, which enters from below, from ledge, is three feet deep and a little lower than the surrounding ground; it is said to overflow all the year round. Surface water is excluded. The spring is at the eastern base of a rocky hill covered with wild shrubs and trees. No pasture within four hundred and fifty feet above. The natural drainage is east, towards Main Street. No buildings on drainage area. The grounds about the spring are resorted to considerably on holidays. Water is sold in Boston, Somerville, Arlington and Cambridge.

Belmont, Belmont Natural Mineral Spring. — This spring is in a valley in a large grassed farm, with considerable underlying rock, covered by loam, about half a mile from Lexington, on J. H. Cotton's estate, and about twelve hundred feet east of his Winter Street buildings. The water rises nearly to the surface of the ground into a reservoir four feet wide and two and a half feet deep, hewn in solid rock, and covered by a stone arch. Surface water is excluded. Drainage from north and west chiefly. No dwelling-houses on drainage area except possibly the Cotton buildings, five hundred feet west, considerably higher than the springs; manure heaps under barn one hundred feet farther. But all the drainage from these buildings would probably flow south, away from the spring. No top-dressing on farm nearer than three hundred feet, and this is on

the east side, where the drainage is probably away from the spring. Market garden, with exposed manure heaps, seven hundred and fifty feet north of spring, which also probably drains away from the spring. A few flower beds around the spring and a little higher, the nearest being forty-five feet, on which a little barnyard manure is used. Pasture five hundred feet north of spring on drainage area. Water is sold in Boston, Waltham, Newton, Lexington, etc.

Boston, Allandale Mineral Spring. — On Allandale Street several hundred feet south from Centre Street, Jamaica Plain. The water rises to within two feet of the surface, in a reservoir seven and a quarter feet in diameter and four and a half feet deep, with stoned and cemented sides and rock bottom. The reservoir is in a small house; surface water excluded; iron pipe; considerable overflow at time of collection. The formation around the spring is mainly gravel and conglomerate. The general direction of the ground water flow is south. The land north of the spring is covered with wild shrubs and trees to a distance of four hundred and fifty feet; beyond are partly grassed fields and pasture land. No buildings on the drainage area within one thousand feet. There is a privy a few hundred feet south, and a little higher than the spring, but there is a dry run between, a little lower than the spring, which would probably lead away any drainage. The grounds around the spring are sometimes used for picnics. The water is sold in Boston, Jamaica Plain, Brookline, etc.

Framingham, Nobscot Mountain Spring. — Large spring at base of ledge east side of Nobscot Mountain. Cemented reservoir, five feet by nine feet and five feet deep; covered by small house; water flows by gravity through block-tin pipe to filling station fifty feet below. Water-shed heavily wooded except directly above spring, where two or three acres have been cleared; no houses on water-shed; used for pasturage to a limited extent. Water sold in Framingham and Boston.

Holbrook, White Rock Spring. — About half a mile from Plymouth Street, a mile from Holbrook Centre. Stoned reservoir, two feet in diameter, three feet deep, one and one-half feet depth of water. Surface water not excluded; no cover; no pump. Said to become dry at times. Flow of water from south-west; no houses in that direction for a mile or more. Drainage area covered by wild growth; no pasture land. Water sold in Holbrook.

Lawrence, Cold Spring. — An open spring in sandy soil; no houses in the immediate vicinity, none on the slope back of the

spring. A small brook runs between the spring and the houses in Lawrence.

Lowell, Sheeprock Spring. — This is an artesian well near the top of a wooded ridge, about eighty feet deep through black granite ledge. All the water is pumped.

Medford, Fulton Natural Spring. — About seventeen hundred feet north-east from corner of Valley and Paris streets, Medford, in Middlesex Fells. A bricked and cemented reservoir, six feet deep and four feet in diameter, in a small house. Water rises from rock at the bottom to within two feet of the surface and overflows; said to overflow all the year round. Drainage is toward the south-west. The spring lies at the base of a rocky hill covered mainly with wild shrubs and trees. There are probably no buildings on the drainage area. Several houses a few hundred feet north-west drain apparently away from the spring. No cultivated land on the drainage area except a well-manured field of about an acre three hundred and seventy-five feet north of the spring. Underground drainage from this may reach the spring, but probably most of it is carried away by a small brook. No pasture land above the spring. Water sold in Medford only.

Medford, Middlesex Mountain Spring. — In Middlesex Fells, on the hill, a few hundred feet north of Valley Street quarry. The water collects in a gravel basin about twelve by fifteen feet and six feet deep, under a large spring house at the eastern base of the ledge. Most of the land above the spring is wild and uncultivated until the farmhouse, No. 15 Earl Avenue, is reached, two hundred feet above. Its surface drainage could not reach the spring. The privy is two hundred and forty-five feet from the spring; its vault rests on a rock, and has earth sides; no exposure of contents. There are no other houses in the vicinity. The houses west of the spring are on the other side of the hill.

Methuen, Otis Spring. — Merely a hole dug in rocky soil two or three feet deep, in a wooded region. Surface water not excluded. No houses within half a mile. Water sold in Lawrence.

Milton, Blue Hill Silver Spring. — Eighty-five feet north from Blue Hill Street, about half a mile east from Canton Avenue, at the southern base of a high, rocky hill, covered with wild shrubs and trees. A stoned and cemented reservoir, three and one-half feet in diameter and five feet deep; water stands two and one-half feet in well and about one and one-half feet below the surface of the ground.

Overflowing when collected. Plank cover; surface water excluded. Portable copper pump with iron pipe used for getting water for sale. Sold in Boston and Milton.

West Lynn, Echo Grove Mineral Spring. — A few hundred feet south-west of house of John Raddin, near corner of Bell Avenue and Ashland Street, West Lynn. Well about thirty-two feet deep, the lower twenty-two feet in solid rock; about ten feet wide at bottom, upper ten feet smaller diameter. Stoned and cemented; stones rest on iron rails ten feet from top. Water is ordinarily about sixteen feet deep, and touches the rails very seldom; it is never dry. Covered by small house, surface water excluded. Drainage is towards the south-west. The well is on a rocky hillside covered with grass and a few trees; used part of the time as pasture. Only houses on drainage area are a few picnic buildings. The privy is eighty-five feet south-east from spring, and higher; contents rest on ground, and are almost completely protected from rain. Water sold in Lynn.

Chelsea, Mt. Washington Spring. — In grassed valley, between Cook and Washington avenues, about three hundred and fifty feet from corner of Fenno Street and Washington Avenue. Bricked reservoir, eight feet in diameter and six feet deep; water rises nearly or quite to the level of the ground. A slight ascent to the nearest privy, which is two hundred and seventy-five feet away, near the corner of Cook and Washington avenues. Its vault is cemented all around. Sink-drain cesspool near by, but no water-closet cesspool anywhere in the vicinity. Several vaults within a few hundred feet more on Cook Avenue, also several vaults and sink cesspools on Washington Avenue, but not nearer than three hundred feet. They are higher than the spring, but a ditch one and one-half feet deep is between them. Lime sludge from soda-water factory is dumped forty-five feet from the spring but probably cannot affect it.

Stoneham, Cedar Park Mineral Spring or Vishnu Mineral Spring. — About three hundred feet south-west from Chapman's Mineral Spring, several hundred feet north from A. Alden's house on Spring Street. Cemented curb two and one-half feet in diameter and six feet deep, in house. Water enters through sand at the bottom, and rises nearly or quite to the level of the ground; said to overflow all the year round; surface water excluded. The well is in a marshy, grassed meadow, containing many ditches; one ditch is within fifteen feet of the well on the side farthest from the ridge

on the south and west, whence comes the ground water. Nearest pasture land one hundred and seventy-five feet above. Nearest considerable sources of contamination are the houses and stables on Spring Street, from five hundred to eight hundred feet away. Water sold in Boston, Melrose, Stoneham, Wakefield, etc.

Lowell, Mt. Pleasant Spring. — A few hundred feet south-east from the corner of Stedman and Westford streets. Stoned and cemented reservoir, nine and one-half feet deep; depth of water three and one-half feet; covered by small house; surface water excluded; no pump; said to overflow all the year round. At the northerly base of a high, sandy hill, covered by pines for a few hundred feet; beyond the pines is wild shrubbery. No pasture land near. Water sold in Lowell.

Brockton, Indian Spring. — About half a mile north from corner of Quincy and Ashland streets; open, stoned reservoir, three by five feet, and three feet deep; depth of water two feet, rises nearly to level of the ground. No covering; surface water partly excluded; considerable overflow at the time of collection. Ground water flows from east and south. Considerable amount of leather chips and a little manure on the road leading to the spring from the east, but most or all of the surface flow from the road is carried beyond the spring. No buildings on the drainage area, which is covered by wild shrubs and trees. No pasture land near the spring. Water sold in Brockton.

West Lynn, Electric Spring. — At southerly corner of Cliff and Linwood streets. Bricked well, four feet diameter at bottom, tapering to top; thirteen feet deep; water rises nearly to level of the ground; overflows all the year round. Covered by house; surface water excluded. In clay and hard blue gravel, at westerly base of a rocky hill covered with shrubbery. Drainage is from north-west and west. Nearest privy is one hundred and fifty feet north-west, on side hill, much above the spring; a shallow vault dug in the earth; contents are slightly exposed. A small garden below the privy, eighty feet west from the well. A stable one hundred and fifty feet north from the well, on higher ground; considerable manure scattered out doors, one hundred and forty feet from the well. But most of the spring water comes from the main hill, farther west. The above are probably the only buildings on the drainage area. Water sold in Lynn only, mainly in summer.

West Springfield, Massasoit Spring. — On the Bear Hole Farm, in mountainous region between Westfield and West Springfield, one or two miles north from the Westfield River. Flows from westerly base of a sandy hill, thirty or forty feet high, into a stoned reservoir, six feet deep, having one hundred square feet of surface; covered by house. Drainage area largely grassed, not ploughed, top-dressed or planted at present. Probably no buildings on drainage area. Grounds west of spring largely used for picnics. Water sold in Springfield.

Stoughton, Crystal Spring. — Several hundred feet easterly from West Stoughton station on the Old Colony Railroad, near Canton Street, on Chas. Porter's farm. Spring boils up at the bottom of a small reservoir, consisting of a brick tile pipe two and one-half feet in diameter and two and one-half feet deep. No covering; surface water not excluded; no pump; said to overflow all the year round. In grassed meadow; drainage from north-west and north-east. Soil about the spring black and peaty near the surface; low, gravelly hills about. Large gardens one hundred and forty feet north; large hen yards two hundred and fifty feet north-east and three hundred feet east. Earth-bottomed barn cellar, containing manure, four hundred and sixty feet east; no out-door manure heap. No houses on drainage area nearer than this barn, and but few beyond. Water sold in Stoughton.

Whitman, Goulding's Spring. — About six hundred to eight hundred feet south-west from corner of High and Temple streets. Cemented curb, two and one-half feet in diameter, four and one-half feet deep; depth of water, three feet; covered by small house; surface water excluded; block tin pipe. Said to overflow all the year round. General direction of ground flow is easterly. Drainage area mainly covered by a wild growth; soil gravelly below, peaty above. Privy about one hundred and fifty feet north-east, and several others within a few hundred feet more in same direction. It is not certain that the drainage from these would reach the spring. Very little direct sale of the water, which is mainly sold bottled.

Brockton, Brockton Mineral Spring. — About a quarter of a mile north north-east from the corner of Quincy and Ashland streets. Stoned reservoir, four feet square and six feet deep; three and one-half feet of water; covered by house; surface water excluded almost entirely; no pump; said to overflow all the year round. Part of the reservoir wall is natural ledge. Ground water flows from the south-

east; no buildings in that direction for a quarter of a mile at least. Drainage area covered by wild growth. A little pasture land about the spring. Water sold in Brockton.

South Easton, Simpson's Spring. — About a quarter of a mile south-west from South Easton station on the Old Colony Railroad. Cemented reservoir, two feet in diameter and four feet deep. Water enters at the bottom, and nearly fills the reservoir; said to overflow all the year round; covered by house; surface water excluded. Spring is on the northerly edge of a meadow in the woods; ground rises to the north and east. Drainage area covered almost entirely by wild growth. No houses nor cultivated land nearer than a small house eight hundred feet north of spring. No other houses near. A few cows are pastured about the spring. Water sold in Brockton, Easton, Bridgewater, etc., also bottled to a large extent.

West Abington, Highland Spring. — About four hundred feet east from house of John Harris, and one thousand to fifteen hundred feet east from Quincy Street, near Brockton line. Stoned reservoir, four feet in diameter, water one and one-half feet deep, nearly at level of the ground; said to overflow all the year round. Planked over; surface water not completely excluded. Gravelly soil; ground water flows from west or south-west. One house, with privy, farm buildings and hen houses, three hundred and sixty feet west south-west from spring, but the ground drainage from these flows probably north-west from spring; the surface flow could not reach the spring. No other buildings on or near the drainage area. The fields on the drainage area are grassed; no pasture land. Water sold in Brockton and Campello.

Allston, Harvard Crystal Spring. — About two hundred feet north from Commonwealth Avenue and five hundred feet west from Harvard Avenue. Stoned and cemented well, five feet in diameter and twelve feet deep; depth of water six feet; said to overflow all the year round. Planked over, and covered by a small house; surface water excluded. Soil gravelly; ground water flows from south-west. Full privy vault, bricked and poorly cemented, one hundred and five feet west, but its drainage is probably away from the well. Another privy vault three hundred and thirty feet south-west from spring; several others beyond. The fields south and west from the spring are gravelly and partly grass-covered. Water sold in Boston, Brighton, Allston, etc.

Brighton, Undine Spring. — About three hundred and fifty feet north from Appleton Road and six hundred feet west from Lake Street. Stoned and cemented reservoir, with plank top about eight by five feet; water three feet deep, and rises nearly or quite to the level of the ground; surface water excluded; said to overflow all the year round. Hard gravelly soil. Ground water flows north. The spring is near the northerly base of a grass-covered hill, not used as a pasture. House, with stable, hen yards, pig-pen and well-manured garden, two hundred and twenty-five feet south-west from spring on hill side. Exposed privy vault three hundred feet south south-west. A few other houses across Appleton Road. Water sold in Boston.

Methuen, Crystal Spring. — In gravelly soil, bricked up to exclude surface water. House and barn three hundred feet distant, and ten to fifteen feet higher than the spring. Two other houses six hundred to nine hundred feet distant.

Brockton, Granite Rock Spring. — On west slope of Carey Hill. Stoned and cemented reservoir, eight by nine feet and five feet deep. Water enters below, through granite ledge; said to overflow all the year round; covered by house; surface water excluded. Gravelly soil; drainage from east. Fields grassed or covered with wild growth. House with vault and hen house one hundred and seventy-five feet up the slope, south-east. Other houses, with barn and manure heap, five hundred to six hundred feet distant, towards the east. Water sold in Brockton and Campello.

Lowell, Hygeia Spring. — In gravelly soil, near foot of wooded ridge. There is some cultivated ground within four hundred to five hundred feet, but the slope is not toward the spring. No houses in the vicinity.

Springfield, Ingersoll Grove Spring. — Flows from east end of a shallow run one hundred feet south from Dartmouth Terrace, several hundred feet west from St. James Avenue. Water is said to collect in a small reservoir concealed in the side of the hill. Overflows through iron pipe. Drainage area is grassed to the streets, eighty to one hundred and twenty feet on north, east and south sides. Sewer in Dartmouth Terrace, about one hundred feet north. Barn one hundred and eighty feet south-east. General direction of drainage is west. It is said there are no cesspools near. Sold largely in Springfield.

Methuen, Burnham Spring. — Just over the Lawrence line. House and stable two hundred to three hundred feet away, and higher. Other houses one thousand feet away, and higher, on the other side of a sand ridge. Land partly under cultivation and partly in grass. Water sold in Lawrence.

Lawrence, Stevens Spring. — On northerly side of Wendell Street; is dug out through the black soil of the meadow to sand, and sheet piling put in around it. The spring is in a low vacant lot, with no houses within eighty or one hundred feet; but the land outside of the lot is thickly built up in all directions. One house, one hundred feet distant, on the opposite side of the street, and one house, one hundred feet distant, on the same side. The street is four or five feet higher than the spring. Houses on Archer Street, two hundred feet northerly, are a little lower than the spring. Cemeteries on the hill to the west, over six hundred feet away.

Dracut, Thisselsia Mineral Spring. — About a quarter of a mile north from the corner of Hildreth and Pleasant streets. Stoned reservoir, four feet in diameter and ten feet deep; depth of water five feet, which comes up through sandy bottom; said to overflow all the year round; covered by small house; surface water excluded. Ground water flows south-west. The spring is in a grassed field; no top-dressing used for several years. One cow is pastured in the field. A cluster of six or eight houses, four hundred to five hundred feet away, and twenty to twenty-five feet higher. Water sold in Lowell.

Lawrence, Knowles Crystal (Diamond) Spring. — In a sandy gravel bank, stoned up. House and stable about one hundred and fifty feet distant, and thirty feet higher. Water sold in Lawrence.

West Lynn, Lovers' Leap Spring. — Under sidewalk of Lovers' Leap Avenue, about one hundred and twenty feet above Forest Street. A bricked and cemented basin, six feet under highway, and a few feet in depth. Water enters at bottom and is carried one hundred and ten feet in an iron pipe to bottling house, corner of Lovers' Leap Avenue and Forest Street. General direction of drainage is east, toward Forest Street. Ledges or low hills on all sides except east. Nearest privy is one hundred and sixty-five feet north-east, stoned sides, earth bottom. Exposed manure heap one hundred feet north. The hillside on the north is occupied by farm buildings. Several more privies on hillside above, within one thou-

sand feet of spring, north-west to south-west. Sold in Lynn; also bottled.

Stoneham, Chapman's Crystal Mineral Spring. — About five hundred feet north from R. B. Chapman's house on Spring Street. A cemented well, two feet eight inches wide and seven and one-half feet deep; water is three feet below surface of the ground, and is said to overflow all the year round. Covered by a small house; surface water excluded. Drainage is from the south-east, south and south-west. The well is at the north base of a gravelly hill; pasturing near the spring. Fields on summit of the hill are grassed and used for pasture to a slight extent. Nearest considerable sources of contamination are very large hen yards and stable two hundred and seventy-five feet south from spring on the hill; manure heap three hundred and fifty feet south. A few other hen yards and manure heaps near these. Water sold in Malden, Melrose, Medford, Boston, etc.

Lexington, Commonwealth Mineral Spring. — On the estate of A. Jameson, about two thousand feet north-east from corner of Woburn and North streets. Reservoir with stone sides, five feet in diameter and seven feet deep. Water rises through gravel bottom and stands three feet deep in reservoir, nearly to the level of the surrounding ground; said to overflow all the year round. Covered by house; surface water excluded. Glass and block-tin pipe to iron pump. The spring is in a grassed meadow basin, among low hills. The soil is black and peaty on top, gravelly below. Drainage is south-east, into Clematis Brook, whose head waters are said to rise in this basin. No top-dressing on drainage area within six hundred feet for several years. Lime sludge from bottling establishment is dumped thirty-five feet east and slightly higher than the spring. Swamp one hundred and seventy-five feet north, just beyond a ditch whose surface is about on a level with the spring overflow. Nearest house is that of the proprietor, nine hundred to one thousand feet south-west. All manure of every kind goes into a barn cellar ten feet deep, with earth bottom. This is on the drainage area. A few other farms on the drainage area between one thousand and two thousand feet from the spring. Water sold in Boston, Cambridge, Waltham, etc.; also used in bottling.

Lowell, Leland Mineral Spring. — A few hundred feet north-east from the corner of Beech and Sixth streets, a few feet below Fremont Street, Centralville, Lowell. Dug well, thirty-five feet deep,

covered by small house; surface water excluded. Said to be never dry. Ground water flows west. Several houses and a few gardens on the long hill above the spring, within a few hundred feet. The houses just across Fremont Street are connected with an iron sewer in that street. The city low-service distributing reservoir is about five hundred feet above the spring. This is the old Lowell Water-cure Spring. Water sold in Lowell.

Brockton, Union Spring. — About five hundred feet south-east from Howard Street and a few feet north-east from Montello Street. Reservoir with planked sides, five by six feet and four feet deep. Water, two feet deep, rises nearly to level of the ground; said to overflow all the year round. Covered by a small house; surface water not completely excluded; a little road wash might enter. Gravelly soil. Well is near the north-east base of a low hill, grass-covered. Nearest source of contamination a cesspool, three hundred and ten feet south-west from spring, on the hillside directly above it. Several more sources of contamination on drainage area within a few hundred feet more. Water sold in Brockton and Campello.

Brockton, Crystal Spring. — Four hundred feet south-west from house of Martin Packard, Pleasant Street, near corner of Pearl Street, Brockton Heights. Stoned and cemented reservoir five by seven feet and four feet deep. Depth of water three feet; said to overflow all the year round. Covered by plank staging; surface water excluded. Water rises in bottom of well through underlying rock. Ground water flows from north-east and east. Drainage area is covered by wild shrubs and trees for two hundred and fifty feet about the spring. Nearest source of contamination is a manure heap, three hundred and seventy-five feet east. Two houses with privy vaults and barns five hundred to eight hundred feet distant from spring. Water sold in Brockton.

Everett, Partridge Spring. — A few hundred feet north-west of the corner of Chelsea and Ferry streets, about one hundred and thirty feet above Chelsea Street. Well is seventeen feet deep in grassed orchard, in a small wooden building. Drainage is south, toward low meadows. Cemented wooden privy vault thirty-six feet west; sink cesspool, ten feet deep, sixty feet south-east; covered manure heap seventy-five feet north-west; water-closet cesspool at next house, about one hundred and fifty feet south-west; several others west to north-east, within six hundred feet.

Everett, Everett Crystal Spring. — At north-west corner of Chelsea and Ferry streets, close to Chelsea Street side-walk. Well twelve feet in diameter and twenty feet deep, in frame house. Overflow into low meadows south of Chelsea Street. Drainage is south towards these meadows. Several wells north on Cottage Street were lowered when this well was dug, eight or ten years ago. The well at one house on Cottage Street, about thirty feet deep and two hundred and eighty-five feet north of the spring, was changed into a cesspool several years ago. Grassed field between the spring and nearest water-closet cesspool. The latter is two hundred and fifty feet north of the spring well, and is not cemented. Several others on Cottage Street near by.

Swampscott, Swampscott Mineral Spring. — One hundred and fifty feet from Essex Street, and about one thousand feet east from corner of Essex Street and Beach Avenue; about six hundred feet north from Moose Hill Spring. The water comes from a driven well sixty feet deep, and runs continually from this through several feet of iron pipe into the spring house south-west. There it runs into a reservoir about five by nine feet, with two and one-half feet depth of water. This reservoir has plank sides and cement bottom; surface water excluded. Considerable dirt and a little green growth on the bottom of the reservoir. Water rises in the well to nearly the level of the surrounding ground, and overflows all the year round. The lower end of the well pipe is in clay. The ground water comes chiefly from the north or north-east. There is a low hill west, separated from the well by a small meadow and a ditch. The well is in a grassed field. The nearest source of contamination is a stable with a manure heap, fifty feet north-east. There is another about the same distance north-west. There are many houses on the drainage area within a few hundred feet. Water sold only in Lynn.

Everett, Belmont Hill Spring. — About one hundred and twenty feet north-west of Bradford Street, Everett, and about six hundred feet west of corner of Hancock. The water rises nearly to the level of the surrounding land in two wells, eight feet in diameter and four feet deep; gravel bottom and stone sides; surface water excluded. The spring is in cultivated land. The nearest cesspool is about one hundred and fifty feet up the hill, *i. e.*, towards Hancock Street; there are several more within a few hundred feet. Several

exposed manure heaps west of the spring, but no opportunity for their surface drainage to enter.

Everett, Glendale Spring. — On Spring Street, about five hundred feet from Ferry Street. Spring rises to level of ground, in cemented enclosure five feet square and three feet deep, and is covered. Overflows several thousand gallons a day. The spring is in Mills' meadows, part pasture and part cultivated. Nearest cesspool is about four hundred feet away, and above, *i. e.*, nearer Ferry Street. This cesspool is cemented all around, and overflows through a pipe into a ditch two hundred and twenty-five feet from the spring at nearest point. Several other cesspools within a thousand feet run into this ditch, which is not higher than the spring. A few houses on the other side of Ferry Street have cesspools which overflow on the ground. Large manure heap two hundred and thirty feet from spring, toward Ferry Street.

Swampscott, Moose Hill Spring. — About one hundred and fifty feet north from corner of Columbia Avenue and Beach Avenue. Bricked and cemented well in large bottling house. The water flows through a crevice in ledge, and rises nearly to the level of the ground in an oblong stone basin, about five feet long, two feet wide and three feet deep; surface water excluded; spring said to overflow the year round. The soil in the neighborhood is chiefly gravel with boulders, with underlying ledge. The drainage is from the south-west and west. The spring house is in a grassed lot. There is a cesspool ninety feet south-west on the hillside, and more cesspools and privies on the hill within three hundred feet. There is a stable fifty feet north-west of the spring. Water sold chiefly in Lynn and Swampscott.

ON THE

AMOUNT OF DISSOLVED OXYGEN

CONTAINED IN

WATERS OF PONDS AND RESERVOIRS

AT

DIFFERENT DEPTHS.

BY THOMAS M. DROWN, M.D., CHEMIST OF THE BOARD.

ON THE AMOUNT OF DISSOLVED OXYGEN CONTAINED IN WATERS OF PONDS AND RESERVOIRS AT DIFFERENT DEPTHS.

The interesting changes in the character of the water of deep ponds, consequent on the stagnation and circulation of the water at different seasons of the year, was discussed in the special report on the Examination of Water Supplies, 1890 (pages 749–767). Investigations of the temperature and composition of the water from different depths in deep ponds showed the presence, in the warmer months, of a stagnant layer of water below a depth of twenty feet from the surface. If the surface of the pond is undisturbed by winds it may reach even to a greater height, say ten feet from the surface. This stagnant layer begins to form in the early part of April, and mingles with the surface water when the circulation of the water takes place in the autumn. This mingling begins in the early part of October and is completed some time in November.

It was stated in the account of this special investigation of deep ponds that the composition of this stagnant water depended upon the amount and character of the impurities in the water, and on the character of the bottom of the pond, whether or not it contained much decomposable organic matter. Thus of seven deep ponds or reservoirs examined it was found that the amount of free ammonia, which may be taken as a measure of the amount of decomposition going on in the stagnant layer, varied from 0.4720 parts per 100,000 in Jamaica Pond, Boston, to 0.0008 parts in the bottom of Reservoir No. 4 of the Boston water supply in Ashland. That the results in these two cases are not accidental is proved by repeated examinations of the deep layers in both of these bodies of water, extending over several years.

The freedom from products of decomposition in the latter case, namely, Reservoir No. 4, is due to the fact that the water is derived from an unpolluted water-shed; that the organic matter which it

contains is derived mainly from swamps and is very slightly disposed to decomposition, and also to the fact that all soil and vegetable matter was carefully removed from the bed of the reservoir before it was filled with water. On the other hand, Jamaica Pond is in a populated region and the bottom contains much readily decomposable organic matter.

In connection with this investigation of the composition of water at different depths it was of interest to determine the amount of dissolved oxygen in the water in the different layers. This determination is best made on the spot, since there is danger of the samples absorbing oxygen from the atmosphere during the transportation to the laboratory.

During the summer of 1891, a considerable number of determinations of the dissolved oxygen were made at different depths, in the waters of many ponds and reservoirs.* The water was pumped up, under proper precautions to prevent access of air, into bottles of known capacity and the chemical reagents added immediately.†

Following are the results of some of the determinations thus obtained. The amount of oxygen present is in all cases expressed as percentages of the amount required to saturate the water at the temperature when collected.

DISSOLVED OXYGEN AT DIFFERENT DEPTHS IN JAMAICA POND, BOSTON.

June 11, 1891.

DEPTH.	Temperature of Water. — Centigrade Degrees.	Amount of Oxygen present in the Water expressed in Percentage of that required to saturate the Water at the Observed Temperature.
Surface,	25	100.00
10 feet below surface,	20	100.00
20 " " "	20	80.00
30 " " "	12	59.03
40 " " "	12	11.10
50 " " "	–	0
57 " " " (bottom),	–	0

* The collection and analysis of these samples were made by Dr. A. H. Gill of the Massachusetts Institute of Technology.

† L. W. Winkler's process (described in the volume on Purification of Sewage and Water, 1890) was used and it is to be recommended for its convenience, simplicity and accuracy. Winkler's original article appeared in the *Berichte*, vol. 21, p. 2843.

DISSOLVED OXYGEN AT DIFFERENT DEPTHS, ETC. — *Concluded.*

June 25.

Depth.	Temperature of Water. — Centigrade Degrees.	Amount of Oxygen present in the Water expressed in Percentage of that required to saturate the Water at the Observed Temperature.
Surface,	21.7	100.00
35 feet below surface,	5.8	37.11
40 " " "	5.8	0
50 " " "	5.6	0

July 14.

Surface,	24.0	100.00
10 feet below surface,	23.8	100.00
20 " " "	12.3	49.00
30 " " "	5.8	29.47
35 " " "	5.6	4.18
40 " " "	5.4	0
47 " " "	5.2	0

In all cases in Jamaica Pond the layers of water which contain no dissolved oxygen have an offensive odor from carburetted and sulphuretted hydrogen. The above series also well illustrates the increase in the thickness of the oxygen-free, stagnant layer as the summer advances.

Glen Lewis Pond, Lynn, is an artificial reservoir, from which the surface soil was not removed. It was first flooded in the latter part of 1889. The water has always contained a large number of animal and vegetable organisms which give it, at most seasons of the year, a very disagreeable appearance and odor. The fact that the oxygen was proved to be absent ten feet from the surface in this pond may be due to the fact that the reservoir is comparatively small (thirty-six acres) and well sheltered from the wind by hills on both sides. It may also be true that the decomposition of the organic matter in this pond is particularly rapid.

DISSOLVED OXYGEN IN GLEN LEWIS POND, LYNN.

June 26, 1891.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	24.2	100
5 feet below surface,	–	100
7 " " "	–	100
10 " " "	–	0
13 feet 6 inches (bottom),	17.2	0

The odor of the water at ten feet below the surface was disagreeable, and that at thirteen feet very offensive. It is interesting to note in this case the abrupt transition, within a distance of three feet, from a water fully saturated with oxygen to one in which the oxygen has been entirely exhausted. This is doubtless owing to the fact that the upper seven feet of water were in circulation through the effect of the wind, and thus exposed to the atmosphere at the surface; because we must assume that at this high temperature decomposition must also be active in the upper layers.

Walden Pond, Lynn, is of the same general character as Glen Lewis Pond. Its depth where samples were taken (June 26, 1891) was ten feet. At this depth the oxygen was only 12.84 per cent. of that required for saturation, and at the surface there was 83.1 per cent.

DISSOLVED OXYGEN IN SCOTT RESERVOIR, FITCHBURG.

June 29, 1891.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	21.4	87.20
10 feet below surface,	18.8	78.70
20 " " "	16.2	32.11
25 " " "	10.2	10.57
30 " " "	–	0
35 " " " (bottom),	–	0

The sample from the bottom had a strong odor of sulphuretted hydrogen; that from the depth of thirty feet, a faint odor. The samples were taken near the gate-house.

Dissolved Oxygen in Lynde Brook Reservoir, Worcester.

July 15, 1891.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
10 feet below surface,	21.1	93.01
25 " " "	16.1	29.14
30 " " "	11.0	0
35 " " " (bottom),	11.0	0

The samples at thirty and thirty-five feet had a strong odor of sulphuretted hydrogen.

Dissolved Oxygen in Lake Cochituate.

August 17, 1891.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	23.6	79.15
10 feet below surface,	19.1	83.60
20 " " "	12.1	35.86
30 " " "	9.6	21.33
40 " " "	9.1	20.93
45 " " "	9.1	1.65
50 " " "	7.6	0
57 " " " (bottom),	7.1	0

The odor of the samples which contained no oxygen was not offensive, simply earthy.

Dissolved Oxygen in Reservoir No. 3, Boston Water Works.

August 20, 1891.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	23.6	85.88
6 feet below surface,	23.6	85.06
12 " " "	21.6	58.97
14 " " "	–	0
15 " " "	–	0
17 " " "	–	0
19 " " "	–	0
21 " " " (bottom),	17.1	0

DISSOLVED OXYGEN IN RESERVOIR NO. 4, BOSTON WATER WORKS.

August 20, 1891.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	23.6	84.50
10 feet below surface,	21.6	84.42
20 " " "	16.6	28.02
30 " " "	21.1	27.42
35 " " "	12.6	16.28
36½ " " " (bottom),	12.6	15.10

The contrast in the condition of the water in these two reservoirs is very striking. Reservoir No. 3, in which the oxygen is exhausted at a depth of fourteen feet, receives a not inconsiderable amount of direct pollution from the towns of Marlborough and Southborough, while the drainage area of Reservoir No. 4, as has been already said, is very sparsely populated.

In connection with the determination of dissolved oxygen in the Ludlow reservoir of Springfield (which contains at all seasons of the year an excessively large number of organisms in suspension in the water) an attempt was made to ascertain whether the amount of dissolved oxygen decreased in the water in its passage through the pipes. It was found that the amount of oxygen was somewhat less after a passage of six miles in the pipes than in the reservoir, and still less after three miles additional passage in the pipes. But the differences are not very great, and it is possible that the loss of oxygen may in part be due to other causes than the decomposition of organic matter.

The reservoir is only ten or thirteen feet deep at the points where the samples were taken, and the comparatively large amounts of oxygen found in the bottom layers of the water indicate, probably, that the water in the reservoir was in circulation by means of the wind.

DISSOLVED OXYGEN, SPRINGFIELD WATER WORKS.

In Large Ludlow Reservoir. July 16, 1891.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	24.1	97.85
10 feet below surface (bottom),	23.6	61.17

In Small Ludlow Reservoir — Gate House.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	24.1	77.60
13 feet below surface (bottom),	23.6	70.58

From Faucet at Indian Leap Hotel, after passing through six miles of pipe.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
	23.6	60.76

From Faucet at Winchester Park, after passing through three additional miles of pipe.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
	23.6	56.98

Some of the water on leaving the pipe passes into an open ditch five hundred feet in length, and then flows swiftly through a trough with a steep grade into Van Horn reservoir. A sample taken at the beginning of the ditch showed 77.49 per cent. of dissolved oxygen, and a sample at the end of the trough 91.28 per cent. These results are both somewhat too high, owing to the impossibility of collecting the samples without access of air; but the greater amount of dissolved oxygen in the water as it flows into the reservoir may be said to represent fairly the effect of aeration in the open ditch or trough.

Van Horn reservoir receives, in addition to the water of Ludlow reservoir, a certain amount of water from its own water-shed (about two hundred and fifty acres), which enters the reservoir mainly after filtering through the ground. Following is a series of determinations of dissolved oxygen in the water of this reservoir at different depths : —

DISSOLVED OXYGEN IN VAN HORN RESERVOIR, SPRINGFIELD.

July 16, 1891.

DEPTH.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Surface,	24.1	100.00
7 feet below surface,	24.1	100.00
14 " " "	24.1	46.43
17 " " "	–	0
20 " " "	–	0
28 " " " (bottom),	–	0

The water from the depth of seventeen feet had an earthy odor; that from the twenty and twenty-eight feet layers, a strong odor of sulphuretted hydrogen.

A consideration of the foregoing determinations of dissolved oxygen in the waters of ponds and reservoirs of different characters leads us to two important conclusions: —

First. That the stagnation of water is not in itself objectionable.

Second. That when a water contains decomposable organic matter, or where water is stored in reservoirs having decomposable matter on its bottom and sides, the oxygen in the water will be quickly used up, and if not renewed the water will become foul.

Reservoir No. 4 of the Boston water supply is the only deep reservoir among those examined which contained some dissolved oxygen (15 per cent.) in the stagnant layer, and this was as late in the summer as August 20. It is not improbable that many natural unpolluted ponds, with sandy bottom, would show even a larger amount of oxygen in the stagnant layer than Reservoir No. 4. If there is nothing to use up the oxygen in solution in the water there is no reason why it should not remain indefinitely. There is always, however, some organic matter in all surface waters, and it is probable that the stagnant layer even in the best ponds is never fully saturated with oxygen. The ordinary process of decomposition of organic matter is one of oxidation and is not necessarily accompanied by offensive odors. In all surface waters which contain vegetable and animal life decomposition is constantly going on, and yet in the presence of an abundance of oxygen there is seldom any objectionable odor; but when the oxygen is exhausted putre-

factive changes set in, and the products then formed are highly offensive. It is under these conditions that sulphuretted, carburetted and phosphoretted hydrogen are developed. These gases we find in water only when oxygen is absent.

In practical water-works management advantage may be taken of the fact of the formation of a stagnant layer in the bottom of deep ponds and reservoirs by drawing the water from near the surface in those cases in which the stagnant layer is foul; but the deterioration of the surface water cannot be prevented when the mingling of all the water takes place in the autumn. In deep storage reservoirs, which must be drawn very low in order to maintain the supply, it may become necessary to draw from the stagnant layer, and if this layer contains products of putrefaction bad water is supplied.

It is not uncommon to find iron in solution, in considerable amount, in the bottom layers of water in deep ponds, when the oxygen is exhausted. Insoluble iron oxide may, under these conditions, be reduced to the lower oxide, and go into solution. In such cases the water may be colorless when pumped up from the bottom but it quickly becomes turbid on exposure to the air, and iron oxide separates out, on standing, as a red deposit.

No stronger argument for vigilance in preventing the contamination of a water supply and for its storage in clean reservoirs could be made than is contained in the results of the foregoing investigation of the changes which organic matter undergoes in water, involving the exhaustion of the dissolved oxygen and the formation of putrefactive products. How far we may expect to remedy the evils consequent on the presence of decomposing organic matter in water by aeration will be discussed in the next chapter of this report.

THE EFFECT OF THE AERATION OF NATURAL WATERS.

By THOMAS M. DROWN, M.D., Chemist of the Board.

THE EFFECT OF THE AERATION OF NATURAL WATERS.

It is a very common belief that water deprived of air will deteriorate in quality, and become unfit for use, and that the only way to maintain its purity is to keep it freely exposed to the air. The mountain stream which breaks over rocks and stones is thought to be a good illustration of the intimate connection between the aeration of water and its purity.

On the other hand, it is not generally known that the waters of many deep wells which we prize for their high purity, their clearness, coolness and good taste, contain no air, and have been preserved in this condition in the earth, for aught we know, for centuries. There is clearly a need of a clarification of our ideas on this subject.

Pure water, preserved from contact with organic matter, remains unchanged indefinitely. If exposed to the air it dissolves a definite amount of the gases of which the air is composed, — nitrogen, oxygen and carbonic acid, — the amount dissolved being dependent upon temperature and pressure. If the pressure is removed, or if the water is boiled, the gases escape, to be reabsorbed when the water is exposed to the air again at ordinary temperatures; but in no sense does the air exert any preservative action on the water or tend to keep it "fresh" or "sweet."

The condition of affairs is, however, entirely changed when water contains organic matter which is capable of undergoing decomposition. The familiar process of the change of organic into mineral matter by *decomposition* is one of oxidation, and the necessity of the presence of air to carry on this change is well understood. The breaking up of organic matter when oxygen is not present is one of *putrefaction*, the products of which are usually very offensive.

The analogy between the comparatively slow process of oxidation in nature and the destruction of organic matter by combustion has

seemed to justify the inference that we can hasten the former as we can the latter by increasing the supply of oxygen. Acting on this assumption, it is not uncommon in waterworks practice to aerate the water by causing it to flow over a series of steps, or by forcing it into the air as a fountain, or by pumping air under pressure into the distribution system. Whatever the method employed for aerating the water, the idea behind it is that the water will be thereby purified by oxidation to a degree beyond that which would take place if the water were exposed to the air on the surface only.

During the past two years numerous experiments have been made in the laboratory of the State Board of Health to test this theory of accelerated oxidation, and all the experiments have given negative results. The question, let it be clearly understood, is not one of supplying oxygen to an impure water, like sewage, which contains no oxygen, but this: Will an impure water, which contains at all times more or less free oxygen in solution, be purified more rapidly by oxidation if the amount of oxygen is increased by spraying the water or by pumping air into it; can the natural process of oxidation be hastened by these means? It is to this question that the experiments give a negative answer. If we look for the cause of this failure to hasten oxidation by increasing the amount of oxygen we find that it rests in the inherent nature of the process, — a process which is only remotely analogous to the chemical process of combustion. In combustion we have the direct chemical combination of carbon and hydrogen with oxygen, and, by varying the supply of oxygen, we can at will make the combustion slow or rapid. The case is entirely different in the oxidation of organic matter in nature. Here we have to do with the living activity of bacteria, which, in some way not fully understood, causes first the carbon and hydrogen of the organic matter and then the nitrogen to combine with oxygen. This process can only be hastened by increasing the number of bacteria, or by providing more favorable conditions for their activity. Thus we know that the temperature at which bacteria are most active differs with different species, but we have no evidence that, provided some free oxygen is present, the activity of the bacteria of decomposition is in the least affected by its amount. Here the analogy of bacterial oxidation and combustion ceases.

The first series of experiments was made to ascertain whether there was any change in the nitrogen compounds in waters under different conditions of aeration, namely: —

1. By exposing water contained in bottles to the air of the room.
2. By drawing a current of air through the water by means of an aspirator.
3. By shaking the water with air in a bottle, in a shaking machine driven by an electric motor, the air being renewed from time to time by removing the stopper from the bottle.
4. By exposing the water to air under a pressure of sixty to seventy-five pounds to the square inch in soda-water siphons.

RESULTS OF AERATION OF WATER BY A CURRENT OF AIR DRAWN THROUGH THE WATER IN A FLASK BY MEANS OF AN ASPIRATOR,* BY AIR UNDER PRESSURE, AND BY SHAKING THE WATER WITH AIR IN A BOTTLE.

First Experiment with Cochituate Water.

[Parts per 100,000.]

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample, ...	.0014	.0182	.0002	.0275
After standing in open bottle for 48 hours,	.0008	.0176	.0005	.0250
After aerating by current of air for 48 hours,	.0014	.0170	.0003	.0250
After standing in open bottle for 216½ hours,	.0036	.0158	.0002	.0250
After standing 49½ hours and then aerating by a current of air for 167 hours, . .	.0026	.0156	.0002	.0250

Second Experiment with Cochituate Water.

Original sample, ...	.0022	.0158	.0000	.0300
After standing in open bottle for 42 hours,	.0024	.0174	.0001	.0380
After aerating 42 hours, ...	.0028	.0160	.0001	.0250
After being under pressure of 72 pounds for 42 hours, ...	.0024	.0160	.0000	.0420
After standing 7 days, ...	.0034	.0150	.0002	.0500

Third Experiment with Cochituate Water.

Original sample, ...	.0022	.0180	.0001	.0500
After standing 48 hours, ...	.0014	.0144	.0000	.0400
After aerating 48 hours, ...	.0016	.0156	.0003	.0400
After being under pressure of 75 pounds for 48 hours, ...	.0018	.0138	.0001	–

* The air used for aspiration was taken from outside the building. The air of laboratories where gas is burned contains enough nitrogen in the form of nitrites to vitiate an experiment of this character.

It was found that there was a very small amount of free ammonia taken up by pure water from the air in the cases of prolonged aeration.

RESULTS OF AERATION OF WATER, ETC. — *Concluded.*

Fourth Experiment with Cochituate Water.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample, ...	.0018	.0140	.0002	.0200
After standing 72 hours, ...	.0016	.0152	.0002	.0300
After aerating 72 hours, ...	.0024	.0142	.0002	.0200
After being under pressure of 75 pounds for 72 hours, ...	.0036	.0150	.0002	.0250

EXPERIMENTS WITH COCHITUATE WATER TO WHICH A SMALL AMOUNT OF SEWAGE HAD BEEN ADDED.

First Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample, ...	.0136	.0220	.0001	.0225
After standing 48 hours, ...	.0108	.0210	.0003	.0500
After standing 70 hours, ...	.0108	.0222	Not det	Not det.
After standing 100 hours, ...	.0128	.0204	.0002	Not det.
After standing 216 hours, ...	.0174	.0190	.0002	.0250
After aerating 48 hours, ...	.0068	.0216	.0005	.0450
After standing 70 hours and shaking 16 hours,	.0124	.0236	Not det	Not det.
After standing 49½ hours and aerating 167 hours, ...	.0104	.0188	.0004	.0250

Second Experiment.

Original sample, ...	.0780	.0300	.0000	.0250
After standing 6½ hours, ...	.0720	.0326	.0000	.0250
After standing 42 hours, ...	.0664	.0372	.0002	.0380
After standing 7 days, ...	.0766	.0226	.0002	.0050*
After shaking 6½ hours, ...	.0740	.0294	.0002	.0250
After being under pressure of 75 pounds for 42 hours, ...	.0584	.0368	.0002	.0260
After aerating 42 hours, ...	.0400	.0402	.0003	.0260

Third Experiment.

Original sample, ...	.0888	.0314	.0000	.0500
After standing 24 hours, ...	.0544	.0332	.0005	.0500
After standing 48 hours, ...	.0358	.0320	.0005	.0400
After shaking 4 hours and standing 20 hours,	.0352	.0426	.0000	.0500
After being under pressure of 75 pounds for 48 hours, ...	.0426	.0288	.0002	.0300
After aerating 48 hours, ...	.0268	.0256	.0003	.0500

* This decrease in nitrates may have been possibly due to the growth of algæ in the bottle.

EXPERIMENTS WITH COCHITUATE WATER, ETC. — *Concluded.*

Fourth Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample,	.0296	.0192	.0001	.0500
After standing 72 hours,	.0256	.0204	.0002	.0300
After standing 7 days,	.0320	.0174	.0003	.0250
After aerating 72 hours,	.0256	.0206	.0004	.0300
After being under pressure of 75 pounds for 72 hours,	.0280	.0210	.0004	.0300

Fifth Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample,	.0486	.0268	.0002	.0775
After standing 24 hours,	.0224	.0322	.0003	.0700
After aerating 24 hours,	.0240	.0326	.0010	.0800
After being under pressure of 75 pounds for 24 hours,	.0310	.0316	.0002	.0825

Sixth Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample,	.0806	.0242	.0002	.0650
After standing 48 hours,	.0528	.0318	.0002	.0380
After aerating 48 hours,	.0496	.0340	.0003	.0380
After being under pressure of 75 pounds for 48 hours,	.0528	.0316	.0001	.0350

Seventh Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample,	.1232	.0304	.0002	.0380
After standing 68 hours,	.0928	.0320	.0002	.0300
After aerating 68 hours,	.0928	.0278	.0005	.0375

Eighth Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample,	.0848	.0294	.0002	.0350
After standing 48 hours,	.0608	.0320	.0002	.0425
After aerating 48 hours,	.0528	.0358	.0003	.0475
After shaking 2 hours,	.0624	.0290	.0001	.0290

Ninth Experiment.

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites.	Nitrogen as Nitrates.
Original sample,	.0832	.0282	.0001	.0475
After standing 5½ hours,	.0752	.0252	.0005	.0500
After shaking 5½ hours,	.0704	.0280	.0008	.0530
After standing 23 hours,	.0586	.0252	.0004	.0420
After standing 23 hours and shaking 7½ hours,	.0544	.0264	.0003	.0350
After standing 72 hours,	.0720	.0202	.0003	.0300
After aerating 72 hours,	.0688	.0250	.0003	.0420

The variations in the amounts of albuminoid ammonia and the nitrates in these experiments are, in general, too small to have any significance, and fall, in most cases, within the limits of accuracy of the processes used. The loss of free ammonia when the water is aerated is an instance of the driving out of one gas by another. Ammonia cannot be completely removed in this way, but when it is present in considerable amount in a water the effect of aeration by a current of air is very marked. When sewage is thus aerated a very considerable amount of free ammonia passes out with the air.

In some cases the changes in the amounts of nitrogen compounds are not easy to explain as the result of any particular treatment. The problem is a complex one. On the one hand we have the tendency of the organic nitrogen to pass into ammonia, and the ammonia to be oxidized to nitrates, and, on the other, the influence of vegetable organisms in directly assimilating the nitrogen of the ammonia and nitrates. Still, the results, as a whole, show plainly that the aeration of water containing nitrogenous matter and ammonia in considerable amount has no tendency to accelerate the oxidation of the nitrogen.

In the foregoing experiments the nitrogen compounds only were investigated. The oxidation of the carbon of the organic matter represented by the albuminoid ammonia would have as a result the formation of more free ammonia; but, as any inference based on the amount of free ammonia might be complicated by its partial removal by aeration, a series of experiments were made to ascertain directly whether any carbon was oxidized by vigorous aeration. In this series only air under pressure was used, and the evidence of the oxidation of carbon was obtained by the "oxygen consumed" from permanganate, which oxidizes only carbon and hydrogen of organic matter, not nitrogen. Should any considerable oxidation of the carbon take place by the oxygen of the air under pressure there would be a considerable reduction of the amount of permanganate used, or of the "oxygen consumed."

Experiments on the Aeration of Cochituate Water by Air under Pressure of Seventy Pounds to the Square Inch.

First Experiment.

[Parts per 100,000.]

	Oxygen Consumed from Permanganate.	
	Without Pressure, Standing in Open Bottle.	Under Seventy Pounds Pressure.
Original sample,	.452	–
After 24 hours,	.421	.488
After 48 hours,	.421	.452
After 5 days,	.478	–

Second Experiment.

	Without Pressure, Standing in Open Bottle.	Under Seventy Pounds Pressure.
Original sample,	.452	–
After 9 days,	.412	.436
After 30 days,	.356	.380

Experiments on the Aeration of Sewage Diluted with Distilled Water.

First Experiment.

[Parts per 100,000.]

	Oxygen Consumed from Permanganate.	
	Without Pressure, Standing in Open Bottle.	Under Seventy Pounds Pressure.
Original sample (sewage, 1 part; water, 5 parts),	.913	–
After 6 days,	.888	.955
After 16 days,	.682	.700

Second Experiment.

	Without Pressure, Standing in Open Bottle.	Under Seventy Pounds Pressure.
Original sample (sewage, 1 part; water, 5 parts),	1.052	–
After 5 days,	.859	.934

Third Experiment.

	Without Pressure, Standing in Open Bottle.	Under Seventy Pounds Pressure.
Original sample (sewage, 1 part; water, 10 parts),	.568	–
After 30 hours,	.539	.542
After 5 days,	.479	.458

Fourth Experiment.

	Without Pressure, Standing in Open Bottle.	Under Seventy Pounds Pressure.
Original sample (sewage, 1 part; water, 15 parts),	.480	–
After 6 days,	.419	.464
After 16 days,	.338	.365

Here, as in the previous series, we find that no more rapid oxidation goes on when the air is under pressure in the water than when the water is exposed to the air at the surface. It may be fairly concluded from the above experiments that oxidation of the elements which go to make up organic matter is a process which cannot be hastened by offering the bacteria, which are the active agents in the process, an excess of oxygen. Their activity is not stimulated in this way.

This is in accord with the interesting investigation of Dr. A. R. Leeds, who examined the water above and below Niagara Falls and found no difference in the free ammonia, albuminoid ammonia and oxygen consumed after this vigorous aeration. An interesting confirmation of the results of these experiments may also be found in the special report on Sewage Purification (1890) in which (pages 730–734) is given an account of experiments to determine the amount of air necessary for a good purification of the sewage by oxidation in intermittent sand filtration. When the atmosphere in the sand of the filter contained from one to three per cent. of free oxygen the oxidation was as complete and rapid as when twenty per cent. (or the full amount in the atmosphere) was present.

Although the strictly chemical theory of oxidation in the aeration of water will have to be abandoned it does not follow that the practice of aeration is not without good effect. It is a well-known fact that one soluble gas passed in a current through water will drive out other soluble gases which may be present in it, provided, there is no chemical combination between the water and gas. The same effect is accomplished by exposing water with any gas in solution to an atmosphere of another gas. Thus when we pass a current of air through water containing sulphuretted hydrogen in solution, the latter is completely driven out, and an offensive water becomes entirely odorless. This is not a case of oxidation, for a current of carbonic acid will effect the same result. In the same way a water which has temporarily a bad odor from an excessive development of algæ, or infusoria, can be rendered quite odorless by sufficient aeration. Even sewage loses its odor when aerated by a current of air for many hours. In these cases the only change effected is the mechanical removal of the soluble gas which is the cause of the odor.

There is another good effect of aeration where it is accompanied by agitation of the water, namely, the prevention of the growth of algæ

with their attendant bad tastes and odors. As is well known, it is only in the comparatively quiet waters of ponds and reservoirs that this annoyance from excessive development of vegetable growth is met with. Moving waters are free from this trouble. It seems a not unreasonable explanation of the fact that an excessive growth of algæ is sometimes stopped by continuous aeration to attribute it to the agitation of the water.

The most rapid means of aerating water are, first, by pumping air into it under pressure, the excess of air escaping when the pressure is removed; second, by breaking it into spray by providing a series of falls, or by means of a fountain jet, or, third, by a fall in a pipe of similar construction to an injector. But these violent methods of supplying oxygen are not necessary if there is circulation in the water of a pond or reservoir whereby all the water in turn is exposed on the surface to the atmosphere.

On the advent of warm weather in the spring of the year the water of any ponds over twenty feet deep may become stagnant at the bottom, and if the water contains decomposable organic matter the oxygen in solution is soon consumed and no more can be obtained from the atmosphere. Under these conditions this stagnant layer becomes very foul from putrefaction. This matter has been very fully studied in the case of Jamaica Pond, Boston, and is described in the report of the State Board of Health on the Examination of Water Supplies, 1890, and also in the previous chapter of this report.

But the water in the stagnant layer does not become foul unless there is decomposable organic matter present. Thus, in Basin 4 of the Boston Water Works, which was carefully prepared for the reception of the water by the removal of all soil and vegetable matter, and is supplied with a brown swampy water from a watershed almost entirely free from population, the water is good at a depth of forty feet, because the water contains very little organic matter with a tendency to decomposition.

The water is *permanently* stagnant during the summer months only below a depth of about twenty feet, because it is turned over by strong winds to this depth in ponds of 100 to 200 acres area. But water may be temporarily stagnant at a less depth in the absence of strong winds. In some ponds we have found oxygen to be absent at the depth of ten feet, and the water to contain much free ammonia and other products of decomposition which were absent in the layers nearer the surface.

Here, as in the previous series, we find that no more rapid oxidation goes on when the air is under pressure in the water than when the water is exposed to the air at the surface. It may be fairly concluded from the above experiments that oxidation of the elements which go to make up organic matter is a process which cannot be hastened by offering the bacteria, which are the active agents in the process, an excess of oxygen. Their activity is not stimulated in this way.

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In cases where it would be possible to bring about a circulation of an entire body of water during the warmer months, so that the lower layers would be brought to the surface and stagnation prevented, we would have effective aeration of the water with the prevention of the accumulation of products of decomposition.

In the case of ground water it is now well understood that the more directly from the ground it is supplied to the consumer the more acceptable it is. It needs no aeration. In fact, its storage in open reservoirs results often in the conversion of a cool, clear, palatable water into one which is repulsive to sight, taste and smell.

There is, however, one class of ground waters, not infrequently met with, which are only fit to use after they have been exposed to the air: namely, waters which contain considerable iron in solution in the form of protoxide. These waters deposit iron oxide on standing, owing to their absorption of oxygen from the air. Aeration in connection with settling basins or filter beds might make waters of this class available for general use.

To resume: —

1. The oxidation of organic matter in water is not hastened by vigorous agitation with air or by air under pressure.

2. The aeration of water may serve a useful purpose, by preventing stagnation, by preventing the excessive growth of algæ, by removing from water disagreeable gases, and by the oxidation of iron in solution.

THE MICROSCOPICAL EXAMINATION OF WATER.

BY GARY N. CALKINS,
ASSISTANT BIOLOGIST OF THE BOARD.

THE MICROSCOPICAL EXAMINATION OF WATER.

In the special report of the Board upon the investigations conducted at the Lawrence Experiment Station on the purification of sewage and water, Professor Sedgwick, Biologist of the Board, has given an historical account of the various methods hitherto employed for the microscopical examination of potable water, and has described an entirely new method introduced by himself for the work of the Board, and afterwards much improved by George W. Rafter, C. E., of Rochester, New York.*

This method, which is now known as the Sedgwick-Rafter method, has been constantly employed in the regular examinations of the drinking waters of Massachusetts for the State Board of Health since Nov. 6, 1890. By its aid and under the supervision of Professor Sedgwick I have made more than 3,000 examinations of potable waters, my whole time having been given to this branch of the biological work.

In the present paper I propose, first, to describe the method in detail — for it is still comparatively unknown — and to suggest certain improvements; and, second, to consider at some length the possible sources of error which its use may involve. I desire to acknowledge my obligations throughout to Professor Sedgwick.

It should be clearly understood at the outset that the microscopical examination of water has nothing to do with the smallest forms of aquatic life (the bacteria) or with the largest forms (such as fishes, frogs, pond-lilies, etc.). For detecting and counting the bacteria special methods, known as "cultures," are indispensable. For recognizing the larger forms the naked eye is sufficient. Between

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* *W. T. Sedgwick.* Recent Progress in Biological Water Analysis. Journal of the New England Water Works Association, September, 1889.

George W. Rafter, C. E. The Biological Examination of Potable Water. Proceedings, Rochester Academy of Sciences, 1890. Rochester, New York.

W. T. Sedgwick. Report of the Biological Work of the Lawrence Experiment Station. Special Report of the Massachusetts State Board of Health on the Purification of Sewage and Water, 1890.

these limits, however, there is a vast host of minute plants and animals, nearly or quite invisible to the naked eye, yet readily studied (as bacteria are not) by the aid of microscopes of ordinary power. These forms abound in lakes and ponds, in open reservoirs and in rivers.

To distinguish them from the bacterial organisms, which cannot so satisfactorily be studied by the aid of the microscope alone, Professor Sedgwick has proposed that they be called the *Microscopical Organisms*, the whole group of small or micro-organisms being sub-divided and defined as follows: —

*Micro-Organisms.** Organisms, either plants or animals, invisible or barely visible to the naked eye.	*Microscopical Organisms* Not requiring special "cultures." Easily studied with the microscope. Microscopic in size or slightly larger. Plants or animals. *Bacterial Organisms* Requiring special cultures. Difficultly studied with the microscope. Microscopic in size. Plants.

By this simple and natural classification all of the lowest plants and animals are grouped together in one great class, viz.: the Micro-Organisms. Most of these, though very small, are still easily studied by the aid of the compound microscope. The members of one group only, the bacteria, are so extremely minute that the microscope fails to reveal most of their peculiarities. The microscopical organisms, therefore, include all of the lowest animals and, excepting the bacteria, all of the lowest plants; but until the Sedgwick-Rafter method was devised there was no satisfactory method for the collection, enumeration and comparison of these organisms in different specimens of water. This method, originally devised to meet the exigencies of the work of the Board, though by no means absolutely perfect, has been found to work very well.

Detailed Description of the Sedgwick-Rafter Method for the Microscopical Examination of Drinking Waters.

The method consists, first, in the *concentration* of all the organisms (except the bacteria) in a measured quantity of the water to be examined by its filtration through sand upon which the organisms are detained; second, in the *separation of the organisms from the*

* See Report of Prof. Sedgwick cited above, page 797.

sand by agitation in a small and known volume of distilled water, followed by rapid decantation; third, in the *microscopical examination* of a measured part of the decanted fluid in which the organisms are suspended; and, finally, from the results of this examination, an *estimation* of the total number and kinds of organisms present.

In the routine work of the Board the measured quantity taken for examination is usually 500 cubic centimeters. This amount is withdrawn before any water is taken from the bottle for other purposes from the large four-liter bottles in which samples of water from the several public water supplies of the State regularly arrive for analysis. Before withdrawing the 500 cubic centimeters, moreover, the bottle is thoroughly agitated in order to dislodge any sediment from the bottom, and to obtain a uniform mixture of the organisms and water.

The microscopical examination is then conducted as follows: The tube of an ordinary six-inch glass funnel is plugged by a perforated rubber stopper, over the upper (smaller) end of which has been laid a circular piece of fine silk bolting-cloth, cut out by a wad-cutter. The stopper should flare but little, and its smaller end should tightly fit the funnel stem, leaving no space between the glass and the rubber. Over the hole in the stopper lies the bolting cloth, which, if laid upon the stopper and moistened, before the latter is inserted into the funnel tube, will adhere to it and form an excellent sieve-like support for the sand afterwards to be poured in from above. Quartz sand, sharp, dry and thoroughly clean, is used for the filtering material, and enough is taken at each time to fill the tube of the funnel to a depth of about one-half an inch above the plug. The sand should be fine enough to pass through a brass seive having 60 meshes to an inch, but not through one having 120 meshes to an inch. It is washed into position and saturated with a small amount of distilled water from a wash-bottle, special care being taken that the distilled water used is fresh and free from organisms. By this previous saturation air-bubbles in the sand are avoided. The funnel thus stoppered with a perforated plug and charged with sand constitutes the filtering apparatus for collecting and concentrating the organisms.

The water to be examined is now thoroughly shaken and poured into the funnel. It runs through the sand more rapidly at first than later, when the filter becomes more efficient through clogging of the inter-

stices between the surface grains. To avoid a small loss of organisms the first 50 cubic centimeters of the filtrate may be poured back into the funnel and made to pass through the filter a second time, although in actual practice this refinement is usually omitted because the error is very small.

After the water has all passed through, the plug is carefully removed and the sand, with whatever organisms have been detained, is washed down into a test tube by five cubic centimeters of distilled water delivered from a graduated pipette. By a rotary motion the contents of the test tube are thoroughly agitated and the organisms are thus freed from the sand. On bringing the tube to rest, the sand, being heavier, quickly settles leaving most of the organisms for an instant in suspension. The supernatant fluid is now rapidly decanted into a second test tube, and, if the process is skillfully done, carries with it most of the organisms, but leaves the sand behind. Care being taken to secure an average sample from about midway between the top and bottom of the five cubic centimeters, one cubic centimeter of the decanted fluid is next withdrawn by a pipette and transferred to the counting plate. This consists of an ordinary glass slide upon which has been cemented a rectangular brass border (20 x 50 millimeters), enclosing an area of exactly one thousand square millimeters. This open chamber is next covered by a piece of thin glass, and, if the brass border is exactly one millimeter in height, must contain exactly one cubic centimeter. As the brass border is cemented to the slide the chamber usually contains slightly more than this and a small bubble of air may, after covering, sometimes remain in the chamber; but if thin cement has been used and if all precautions be taken, the chamber may be made to contain almost exactly one cubic centimeter.

Great care must be taken from the very beginning to secure average samples and at the end to obtain an even distribution of the organisms upon the counting plate. I have found that the latter may be obtained by proper arrangement of the cover glass. The glass is laid diagonally over the cell in such a manner that an opening about four millimeters wide is left in a corner at one end. At the corner opposite there is a small opening for the escape of air. The sample to be examined issues from the pipette into the larger opening and by capillary action completely fills the cell, and gives an even distribution of the organisms contained in it.

The counting chamber, having been filled with the sample to be examined, must obviously contain one cubic centimeter of the decanted fluid, in which there must be one-fifth of the total number of organisms separated by filtration from the original sample; so if 500 cubic centimeters, for example, were originally taken, the contents of 100 cubic centimeters are now ready for inspection within the counting chamber. We may, therefore, at our convenience, examine qualitatively the organisms present, using a comparatively low power, *e. g.*, the B or C objective of Zeiss.

To make the examination quantitative it is only necessary to place in the ocular of the microscope a unit measure of the area of the counting plate. This is readily effected by placing upon the diaphragm of the eye-piece an ocular micrometer consisting of a glass disc upon which is marked a square of such size that it can be adapted, with the objective used, to cover exactly one square millimeter of the counting plate. In order to exclude all objects not falling within the square millimeter to be examined, the disc, if it is preferred, may be blackened outside the ruled square. The square alone answers very well, and was used for a long time; afterwards it was subdivided by two fine lines into four smaller squares, and more recently it has been still further subdivided with advantage. It is hardly necessary to add that this ocular square must be carefully standardized for different powers. Having thus standardized it, it is only necessary to remember that the field or aperture of the ocular diaphragm corresponds to an area of one square millimeter and also covers a volume of one cubic millimeter upon the counting plate.

If the contents of this cubic millimeter be noted, and other portions of the plate be similarly examined, we are obviously able to arrive at an approximately accurate idea of the kinds and numbers of microscopical organisms before us; but, inasmuch as the plate contains 1,000 cubic millimeters, it is clearly impracticable to count, or even to scrutinize, the contents of all of these. In practice, only 20 "fields," or cubic millimeters, are ordinarily examined, *i. e.*, one-fiftieth of the whole number. This means that if 500 cubic centimeters were originally taken, and one-fifth of all the organisms in the original measured quantity is before us on the counting plate, evenly distributed throughout 1,000 cubic millimeters, we might, if time allowed, actually examine the contents of every one of these.

Practically, however, it suffices to examine 20 representative cubic millimeters, which, indeed, correspond to only 2 cubic centimeters of the original 500. If, however, the 20 fields actually examined fairly represent, as they should, the whole 1,000 before us, it is evident that by the examination of 20 representative fields we have obtained an approximately accurate knowledge of the contents of 100 of the original 500 cubic centimeters. Furthermore, inasmuch as the original measured quantity must have had the organisms which it contained tolerably evenly distributed within it, we may reasonably suppose that what is true of one-fifth must be equally true of the other four-fifths. In other words, if the whole contents be concentrated, and of these one-fifth taken at random be examined in thousandths by 20 separate, but representative, examinations, we shall have an approximately, though not an absolutely, exact knowledge of the amount and the nature of the original contents. It clearly becomes important that the twenty squares actually examined should be representative; and to this end it is necessary to resort to special precautions. Mr. Rafter (loc. cit.) employs for the purpose a simple mechanical stage. I have found it sufficient, however, to examine successively different fields systematically taken from left to right and from top to bottom, or *vice versa*.

For recording the results in the laboratory the accompanying blank form has been found useful, and, to give an example, it has been filled out with an ordinary analysis of water from Springfield. The written matter upon the original form is printed in italics.

A record sheet is also given upon which are reported the results of the examinations made during each week. To show how this is used I have filled one of the columns with the results of the examination of Springfield water as already given on the specimen laboratory sheet.

System of Enumeration.

It has been a matter of much difficulty to determine the best system to adopt in enumerating microscopical organisms. Some of these occur as one-celled individuals, others as many-celled individuals, others as collections of cells united into filaments which may be either long or short, and still others as collections of individuals united into colonies which may be either large or small. The problem to be solved is how best to enumerate these different kinds and forms so as to have results which shall be comparable. We

...sults—... Board of Health.

...MINATION OF WATER.

...No. ... BIOLOGIST'S NUMBER, 6724.

...EXAMINED, ½ 500. CHEMIST'S NUMBER, 5238.

...SAMPLE, 1 foot. TEMPERATURE,

1...	12	13	14	15	16	17	18	19	20	Total.	No. in 100 c.c.
52										904	452.00
4		2	4							15	7.50
										2	1.00
48										96	48.00
	1									1	.50
							1	1		5	2.50
4[illegible]										88	44.00
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										1	.50
										2	1.00
										1	.50
							1			1	.50
										1	.50
					1		2		1	6	3.00
					1					5	2.50
76										152	76.00
[illegible]	1	1			1	1		2	2	19	9.50
[illegible]	1				1		1	1	1	18	9.00
4[illegible]										88	44.00
[illegible]										76	38.00
	1	1	3		1		3		4	24	12.00
										2	1.00
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may have, for example, 1,000 colonies of *Synura* in one sample, or at one time, in which the average number of individuals to a colony is 10, and 1,000 colonies in another sample, or at another time, in which the average number per colony is 8. The results, though equal on the report sheet, obviously give imperfect ideas of the actual numbers of organisms and the total quantity of organic matter. In one case there would be 10,000 individual organisms and in the other only 8,000. Again, *Anabœna* is enumerated as a filament. In one sample the average number of cells to a filament may be 20, and in another sample only 10. If 500 filaments be counted in each case, there is nothing to indicate that, in equal volumes of water, the first sample contains twice as much *Anabœna* substance as the second.

In an ideal method of counting, all cells should be enumerated, since these are the ultimate morphological and physiological units; but in practice this is impossible, and certain organisms or groups must be enumerated as aggregates of cells (*e. g.*, some Infusoria such as *Uroglena*, and some Algæ such as *Sorastrum*, *Cœlastrum* and *Pediastrum*). This is allowable, of course, when the forms and sizes of the organisms are invariable, for in that case the results must always be comparable.

The following is the system in use at present, which has been found to work very well. It is, however, the result of numerous experiments, and represents in a measure the provisional work by which a method for the microscopical examination of potable waters was step by step elaborated.

Present System of Enumeration.

In the following the *individual* is taken as the unit: —

All *Diatoms*
All *Desmids.*
All *Rhizopods.*
All *Vermes*, except *Conochilus volvox.*
All *Crustacea.*
All *Infusoria*, except *Synura*, *Uvella* and *Uroglena volvox.*
Characium.
Chlorococcus.
Chroöcoccus.
Dictyosphærium.
Eudorina.
Ophiocytium.
Pandorina.
Protococcus.
Raphidium.
Saccharomyces.
Scenedesmus.
Spirulina.
Zoöspores.

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may have, for example, 1,000 colonies of *Synura* in one sample, or at one time, in which the average number of individuals to a colony is 10, and 1,000 colonies in another sample, or at another time, in which the average number per colony is 8. The results, though equal on the report sheet, obviously give imperfect ideas of the actual numbers of organisms and the total quantity of organic matter. In one case there would be 10,000 individual organisms and in the other only 8,000. Again, *Anabœna* is enumerated as a filament. In one sample the average number of cells to a filament may be 20, and in another sample only 10. If 500 filaments be counted in each case, there is nothing to indicate that, in equal volumes of water, the first sample contains twice as much *Anabœna* substance as the second.

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All *Crustacea.*
All *Infusoria*, except *Synura*, *Uvella* and *Uroglena volvox.*
Characium.
Chlorococcus.
Chroöcoccus.
Dictyosphærium.
Eudorina.
Ophiocytium.
Pandorina.
Protococcus.
Raphidium.
Saccharomyces.
Scenedesmus.
Spirulina.
Zoöspores.

In the following the *filament* is the unit: —

Anabæna.	*Leptothrix.*
Beggiatoa.	*Nostoc.*
Bulbochæta.	*Œdogonium.*
Cladophora.	*Oöcystis.*
Cladothrix.	*Oscillaria.*
Conferva.	*Rivularia.*
Crenothrix.	*Spirogyra.*
Cylindrospermum.	*Ulothrix.*
Draparnaldia.	*Zygnema.*

In the following the *thallus* is the unit: —

Aphanocapsa.	*Merismopedia.*
Clathrocystis.	*Micrococcus.*
Cœlosphærium.	*Microcystis.*
Glœocapsa.	*Zoöglœa.**
Glœocystis.	

In the following the *colony* is the unit: —

Botrycoccus.	*Staurogenia.*
Conochilus volvox.	*Synura.*
Gonium.	*Tetraspora.*
Palmella.	*Uroglena volvox.*
Pediastrum.	*Uvella.*
Pleurococcus.	*Volvox.*
Sorastrum.	

It will be seen from this list that some genera of filamentous forms are enumerated according to the number of individual cells. This is the case with *Melosira*, *Fragilaria*, *Striatella* and *Grammatophora* (diatoms); *Bambusina*, *Desmidium*, *Hyalotheca* and *Sphærozosma* (desmids). These forms, however, are comparatively rare and their enumeration is relatively of less consequence than that of the more important and common forms of filamentous plants which are counted as filaments; such forms are *Anabæna* and the other filamentous blue-green varieties. Some organisms which form colonies are counted as individuals while others are counted as colonies.

As has been intimated already this system of enumeration, adopted in the early stages of the work, has answered very well and has given valuable and entirely comparable results. With the large numbers of waters to be examined it has been found necessary, however, not

* Zoöglœa is enumerated by units of area each of which is equal to 2,500 square microns or .0025 square millimeters.

only to limit the number of cubic millimeters actually examined upon the counting plate but also to disregard interesting problems, such as the differences in size or mass of different individuals of the same species, or of individuals of different species or genera. Moreover, in order to secure the immediate practical results for which the work was instituted, relative were often more useful than absolute results. Thus it has come to pass that modifications which experience has shown to be useful in the system of enumeration might well be adopted in undertaking an entirely new set of investigations, or for purely scientific purposes, but of more doubtful value in work already well advanced or work in which comparable and relatively accurate are of more importance than absolutely accurate results. For new work, or for work intended, for example, to ascertain the approximate amount of organic matter present in the form of microscopical organisms, I should recommend a system of enumeration based upon totality, area and length, instead of the arbitrary use of the biologically inexact term, an "individual."* But it is obvious that even this system would fail to give precise quantitative results. Neglecting such questions as specific gravity or density we even fail to obtain specific volumes; and this must continue to be the case so long as individuals vary in size, colonies in depth, and filaments in diameter.

Sources of Error in the Sedgwick-Rafter Method.

A. Errors in collecting Samples to be Examined.

The results of microscopical examinations of water to have the greatest value should be taken in conjunction with other information. In a given sample of water collected and sent to the laboratory for examination we find only the organisms suspended in the reservoir or other source. Filamentous algæ with various forms of life attached to them do not, as a rule, come to our notice in such samples, for these organisms are attached to rocks or to the bottom in shallow portions of the water, or float in conspicuous isolated masses which are avoided by the collector of water samples. I have found Zygnemaceæ abundant on the edges of reservoirs in

* There should be three units in this proposed system, one of mass, one of area and one of length. Individual cells such as Diatomaceæ and Desmidiæ, fixed aggregates of cells such as Volvocineæ and many Protococcoideæ, and individuals such as Rhizopoda, Crustacea, Vermes, etc., are all enumerated as units of mass. Aggregations composed of cells so minute that it is impracticable to distinguish them are enumerated by units of area or by units of length.

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Conferva.	*Rivularia.*
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Draparnaldia.	*Zygnema.*

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Glœocapsa.	*Zoöglœa.**
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Gonium.	*Tetraspora.*
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different parts of the State with no sign of them whatever in the regular samples collected and sent at the same time to the laboratory. The sides and bottoms of reservoirs, etc., and the plants there growing are the homes of many low forms of life, and a failure to make allowance for their existence may cause grave misinterpretation of the biological conditions of the water supply in which they dwell.

The place at which a sample is taken may make a great difference in the number of organisms present, for it may be taken at different points upon the system or from a pipe which has been but little used. A heavy rainfall may also disturb the usual conditions of the water; or the sample may be taken at one time when the sky has long been clouded over, while the next sample from the same place may be taken after days of bright sunshine. Winds, also, materially influence the distribution of microscopical organisms in reservoirs, etc., while the constant outflow at that point brings towards the gate-house and tends to accumulate there an excess of the ordinary floating forms. All of these are initial sources of error of collection which may exist no matter what method of concentration or enumeration be used, and they all influence more or less the monthly and yearly sequence of organisms actually discovered or enumerated in the samples submitted to the microscopist.

B. Errors in withdrawing Samples from Bottles.

In the regular work of the State Board of Health of Massachusetts samples of water are sent to the laboratory in large four-liter bottles, from which must be taken different portions for the microscopical and chemical examination of the different substances in suspension and in solution. Here also great care must be taken to secure an average sample of the contents of the bottle for microscopical examination. Organisms are very apt to arrange themselves unevenly; some rise to the surface of the water, some fall to the bottom and others arrange themselves on the side nearest the light, or farthest from the light.

The following experiment was made, in order to learn how the examination may be affected by carelessness in withdrawing the sample from the bottle. Four samples, as sent in, were allowed to stand over night. The next morning, by means of a siphon, portions were carefully drawn off from near the surface and from near the

bottom (columns 1 and 2). The columns marked 3 show the results of examinations of portions taken from the same bottles after the contents had been thoroughly agitated and mixed. The higher numbers in this column are probably due to the complete dislodgement and thorough distribution of the sediment, and these numbers, therefore, are nearer the truth.

TABLE I. — *Showing Possibility of Error from Carelessness in withdrawing Samples for Examination.*

GROUPS.	Sample No. I.						Sample No. II.					
	Total Organisms Observed.			Number of Kinds Observed.			Total Organisms Observed.			Number of Kinds Observed.		
	1	2	3	1	2	3	1	2	3	1	2	3
Diatomaceæ, . . .	67	110	184	5	6	7	50	88	150	2	5	4
Cyanophyceæ, . .	32	67	103	5	5	6	0	37	29	0	2	4
Algæ, ...	33	51	78	7	6	6	7	61	43	3	4	6
Fungi, ...	34	35	23	2	1	1	160	100	565	1	1	2
Infusoria, . . .	2	27	8	2	2	3	1	1	13	1	1	2
Other objects, . .	7	2	0	3	2	0	4	17	8	3	5	3
Total Organisms,	175	292	396	24	22	23	222	304	808	10	18	21

TABLE I. — *Concluded.*

GROUPS.	Sample No. III.						Sample No. IV.					
	Total Organisms Observed.			Number of Kinds Observed.			Total Organisms Observed.			Number of Kinds Observed.		
	1	2	3	1	2	3	1	2	3	1	2	3
Diatomaceæ, . . .	66	91	153	6	5	5	16	75	259	5	8	8
Cyanophyceæ, . .	121	178	137	4	5	5	64	168	241	1	2	3
Algæ, ...	37	35	74	6	8	11	69	202	164	7	7	6
Fungi, ...	160	112	344	1	1	1	22	51	119	2	2	2
Infusoria, . . .	129	28	21	2	3	6	4	3	13	2	1	4
Other objects, . .	21	8	11	4	2	2	3	4	2	2	2	2
Total Organisms,	534	452	740	23	24	30	178	503	798	19	22	25

Here, and throughout the entire investigation, in order to avoid all possible bias, no results were worked out until all observations had been made and recorded. It is interesting to observe, in passing, that these results serve to show the comparative worthlessness of the older methods depending upon the examination of sediments only.

Another error may arise if the biological sample is not taken before different portions of the contents of the bottle are poured off for other purposes, as, for example, for some determination in the chemical examination, for which it is not necessary to shake and mix the sample. If the portions for chemical examination are taken out first, some organisms, chiefly diatoms and the heavier algæ, may have sunk to the bottom and have thus become concentrated into a smaller residual volume of water. If this has happened the enumeration of organisms afterwards must give erroneous results. It is therefore safer to withdraw the portion for microscopical examination when the samples are first opened. In winter, however, the samples cannot be filtered until they have acquired the temperature of the room, for cold water contains more dissolved air than warm water, and hence air bubbles are formed in the filter if the sample when cold be filtered in a warm room, and these clog the filter or perhaps stop it altogether. In order to overcome this difficulty and the error just alluded to, I am accustomed, as soon as the bottles arrive, to withdraw the portions for microscopical examination into liter flasks, in which they stand until they have acquired the temperature of the laboratory.

C. Errors in Concentration.

(1.) The sloping sides of a glass funnel offer a surface for the settling of organisms, and the error arising in this way may be considerable. A water free from amorphous matter and *Zoöglœa* will filter very accurately, but a water containing these gives opportunity for error. To find the amount of this error several samples of water have been examined, some free from *Zoöglœa*, others having it in great abundance. After filtering 500 cubic centimeters and collecting the suspended matter as usual, the sides of the funnel which had been used were thoroughly washed with distilled water, which was then filtered as before. Obviously this experiment should give the greater part of the residue of the organisms in 500 cubic centimeters which had been deposited on the funnel sides. In the case of waters free from *Zoöglœa* the error never exceeded 0.8 per cent. but it rose as high as 2.0 per cent. for water from the Blackstone River in which *Zoöglœa* is very abundant. This is probably due to the jelly-like character of the *Zoöglœa* which makes it sticky, and to the fact that while adhering to the funnel sides itself, it also retains with it some organisms. In all cases, however, this error can be largely avoided by passing the water through the

funnel a second time and refiltering, provided the *Zoöglœa* is not allowed to dry on the sides of the funnel. In actual practice this is not done because the error is usually so small.

The following table shows the average percentage of error from this source. In all cases the figures represent the number of organisms in one cubic centimeter of the sample.

TABLE II. — *Showing Error caused by Organisms adhering to Sides of Funnel.*

GROUPS.	SAMPLE I.			SAMPLE II.			SAMPLE III.		
	Organisms Observed. By usual Method.	Organisms Observed. After washing Funnel or Funnel Error.	Percentage of Funnel Error to Total Organisms.	Organisms Observed. By usual Method.	Organisms Observed. After washing Funnel or Funnel Error.	Percentage of Funnel Error to Total Organisms.	Organisms Observed. By usual Method.	Organisms Observed. After washing Funnel or Funnel Error.	Percentage of Funnel Error to Total Organisms.
Diatomaceæ, . . .	5,053	14	.27	6,222	9	.14	13	0	0
Cyanophyceæ, . . .	190	1	.52	253	0	0	299	0	0
Algæ, ...	103	0	0	138	0	0	91	1	1.10
Fungi, ...	2	0	0	3	0	0	10	0	0
Rhizopoda, . . .	9	0	0	4	0	0	5	0	0
Infusoria, ...	47	3	6	53	5	8.6	41	2	4.6
Vermes, ...	2	0	0	2	0	0	1	0	0
Crustacea, . . .	0	0	0	0	0	0	1	0	0
Zoöglœa, ...	114	0	0	136	1	.73	64	0	0
Other objects, . . .	2	0	0	0	0	0	0	0	0
TOTAL ORGANISMS, .	5,522	18	.32	6,811	15	.22	525	3	.57

TABLE II. — *Continued.*

GROUPS.	SAMPLE IV.			SAMPLE V.			SAMPLE VI.		
	Organisms Observed. By usual Method.	Organisms Observed. After washing Funnel or Funnel Error.	Percentage of Funnel Error to Total Organisms.	Organisms Observed. By usual Method.	Organisms Observed. After washing Funnel or Funnel Error.	Percentage of Funnel Error to Total Organisms.	Organisms Observed. By usual Method.	Organisms Observed. After washing Funnel or Funnel Error.	Percentage of Funnel Error to Total Organisms.
Diatomaceæ, . . .	9	3	25.0	30	0	0	40	2	4.8
Cyanophyceæ, . . .	324	1	.3	10	0	0	12	0	0
Algæ, ...	72	0	0	8	0	0	1	0	0
Fungi, ...	6	0	0	1	0	0	0	0	0
Rhizopoda, . . .	1	0	0	0	0	0	0	0	0
Infusoria, ...	61	0	0	129	1	.77	69	0	0
Vermes, ...	1	0	0	0	5	100	2	0	0
Crustacea, . . .	1	0	0	0	0	0	0	0	0
Zoöglœa, ...	78	1	1.3	13	0	0	28	1	3.4
Other objects, . . .	2	0	0	0	5	100	0	0	0
TOTAL ORGANISMS, .	555	5	.89	191	2	1.04	152	3	1.9

TABLE II. — *Concluded.*

GROUPS.	Sample VII. Organisms observed. By usual Method.	Sample VII. Organisms observed. After washing Funnel or Funnel Error.	Sample VII. Percentage of Funnel Error to Total Organisms.	Sample VIII. Organisms observed. By usual Method.	Sample VIII. Organisms observed. After washing Funnel or Funnel Error.	Sample VIII. Percentage of Funnel Error to Total Organisms.	Summary. Organisms observed. Total Organisms Found by usual Method.	Summary. Organisms observed. Total Organisms washed from Funnel Sides.	Summary. Average Percentage of Funnel Error to Total Organisms.
Diatomaceæ, . . .	30	0	0	39	0	0	11,436	28	.25
Cyanophyceæ, . . .	2	0	0	0	0	0	1,090	2	.19
Algæ, ...	996	0	0	888	0	0	2,297	1	.04
Fungi, ...	4	0	0	18	0	0	44	0	0
Rhizopoda, . . .	0	0	0	0	0	0	19	0	0
Infusoria, ...	2	0	0	0	0	0	402	11	2.66
Vermes, ...	1	0	0	0	0	0	9	.5	5.55
Crustacea, . . .	0	0	0	0	0	0	2	0	0
Zoöglœa, ...	90	0	0	27	1	3.6	550	4	.72
Other objects, . . .	1	1	50	0	0	0	5	1.5	23.08
TOTAL ORGANISMS, .	1,126	1	.09	972	1	.10	15,854	48	.30

It is seen from this table that in only two cases out of the eight, does the error for the total organisms rise above one per cent. The final column shows the error per cent. for all groups of organisms for eight cases. The error, 0.3 per cent., is so small that for all practical purposes it may be disregarded.

(2.) Another and greater source of error exists when the attempt is made to separate the organisms from the sand, by agitating the sand with distilled water in one test tube and decanting the supernatant liquid as promptly as possible into another tube. Some of the organisms necessarily remain with the sand. For convenience, the error arising in this way will be called the "decantation" error. In the experiments to determine the amount of this error the residual sand was washed thoroughly a second time with five cubic centimeters of fresh distilled water, in order to get what organisms might have been left after the first decanting. After carefully agitating the sand in this fresh water to detach the organisms, the liquid was decanted into a second test tube as before. Of this liquid one cubic centimeter was examined and the organisms found were taken to represent the "decantation" error.

TABLE III. — *Showing the Decantation Error.*

GROUPS.	SAMPLE I.			SAMPLE II.			SAMPLE III.		
	ORGANISMS OBSERVED.		Percentage of Decantation Error to Total Organisms Observed.	ORGANISMS OBSERVED.		Percentage of Decantation Error to Total Organisms Observed.	ORGANISMS OBSERVED.		Percentage of Decantation Error to Total Organisms Observed.
	By usual Method.	After Second Decantation or Decantation Error.		By usual Method.	After. Second Decantation or Decantation Error.		By usual Method.	After Second Decantation or Decantation Error.	
Diatomaceæ,	216.0	24.0	10.0	172.0	18.5	9.7	259.0	43.0	14.2
Cyanophyceæ,	210.5	1.0	.47	270.0	0.5	0.18	241.0	4.0	1.6
Algæ,	124.5	2.5	1.97	120.5	0.5	0.44	165.0	5.0	2.9
Fungi,	79.5	1.0	1.2	176.5	2.0	1.10	119.0	3.0	2.5
Rhizopoda,	0	0	0	0	0	0	0	0	0
Infusoria,	8.0	0	0	1.5	0.5	25.00	13.0	4.0	23.5
Vermes,	1.0	0.5	33.3	0.5	0	0	0	0	0
Other objects,	0	0	0	0	0	0	2.0	0	0
TOTAL ORGANISMS,	639.5	29.0	4.3	741.0	22.0	2.9	799.0	59.0	6.9

TABLE III. — *Continued.*

GROUPS.	SAMPLE IV.			SAMPLE V.			SAMPLE VI.		
	ORGANISMS OBSERVED.		Percentage of Decantation Error to Total Organisms Observed.	ORGANISMS OBSERVED.		Percentage of Decantation Error to Total Organisms Observed.	ORGANISMS OBSERVED.		Percentage of Decantation Error to Total Organisms Observed.
	By usual Method.	After Second Decantation or Decantation Error.		By usual Method.	After Second Decantation or Decantation Error.		By usual Method.	After Second Decantation or Decantation Error.	
Diatomaceæ,	156.0	36.0	18.7	58.0	6.0	9.4	151.0	34.0	18.4
Cyanophyceæ,	143.0	8.0	5.3	15.0	1.0	6.3	55.0	3.0	5.2
Algæ,	77.0	13.0	14.4	84.0	0	0	35.0	10.0	22.2
Fungi,	55.0	8.0	12.7	24.0	3.0	11.1	81.0	2.0	2.4
Rhizopoda,	0	0	0	0	1.0	100.0	1.0	0	0
Infusoria,	2.0	1.0	33.3	8.0	0	0	25.0	5.0	16.7
Vermes,	0	0	0	1.0	0	0	0	1.0	100.0
Other objects,	1.0	0	0	1.0	0	0	2.0	0	0
TOTAL ORGANISMS,	434.0	66.0	13.2	191.0	11.0	5.4	350.0	55.0	13.6

TABLE III. — *Continued.*

GROUPS.	SAMPLE VII. Organisms Observed. By usual Method.	SAMPLE VII. Organisms Observed. After Second Decantation or Decantation Error.	SAMPLE VII. Percentage of Decantation Error to Total Organisms Observed.	SAMPLE VIII. Organisms Observed. By usual Method.	SAMPLE VIII. Organisms Observed. After Second Decantation or Decantation Error.	SAMPLE VIII. Percentage of Decantation Error to Total Organisms Observed.	SAMPLE IX. Organisms Observed. By usual Method.	SAMPLE IX. Organisms Observed. After Second Decantation or Decantation Error.	SAMPLE IX. Percentage of Decantation Error to Total Organisms Observed.
Diatomaceæ, ...	110.0	7.0	6.0	184.0	18.0	8.9	8.8	14.0	13.7
Cyanophyceæ, . . .	67.0	0	0	103.0	3.0	2.8	37.0	0	0
Algæ, ...	51.0	0	0	78.0	0	0	61.0	0	0
Fungi, ...	35.0	3.0	7.9	23.0	2.0	8.0	100.0	12.0	10.7
Rhizopoda, . . .	1.0	0	0	0	0	0	2.0	0	0
Infusoria, ...	27.0	1.0	3.6	8.0	1.0	11.1	1.0	0	0
Vermes, ...	0	0	0	0	0	0	14.0	0	0
Other objects, . . .	1.0	0	0	0	0	0	1.0	0	0
TOTAL ORGANISMS, .	292.0	11.0	3.6	396.0	24.0	5.7	304.0	26.0	7.9

TABLE III. — *Continued.*

GROUPS.	SAMPLE X. Organisms Observed. By usual Method.	SAMPLE X. Organisms Observed. After Second Decantation or Decantation Error.	SAMPLE X. Percentage of Decantation Error to Total Organisms Observed.	SAMPLE XI. Organisms Observed. By usual Method.	SAMPLE XI. Organisms Observed. After Second Decantation or Decantation Error.	SAMPLE XI. Percentage of Decantation Error to Total Organisms Observed.	SAMPLE XII. Organisms Observed. By usual Method.	SAMPLE XII. Organisms Observed. After Second Decantation or Decantation Error.	SAMPLE XII. Percentage of Decantation Error to Total Organisms Observed.
Diatomaceæ, ...	150.0	10.0	6.3	67.0	9.0	11.8	177.0	15.0	7.8
Cyanophyceæ, . . .	29.0	0	0	0	0	0	7.0	0	0
Algæ, ...	43.0	2.0	4.4	100.0	2.0	1.9	39.0	0	0
Fungi, ...	565.0	134.0	19.2	64.0	5.0	7.2	501.0	23.0	4.4
Rhizopoda, . . .	1.0	0	0	2.0	0	0	1.0	0	0
Infusoria, ...	13.0	0	0	0	0	0	2.0	0	0
Vermes, ...	2.0	0	0	3.0	0	0	1.0	0	0
Other objects, . . .	5.0	2.0	28.6	1.0	0	0	0	0	0
TOTAL ORGANISMS, .	808.0	148.0	15.5	237.0	16.0	6.3	728.0	38.0	4.9

TABLE III. — *Continued.*

GROUPS.	Sample XIII. Organisms observed. By usual Method.	Sample XIII. After Second Decantation or Decantation Error.	Sample XIII. Percentage of Decantation Error to Total Organisms Observed.	Sample XIV. Organisms observed. By usual Method.	Sample XIV. After Second Decantation or Decantation Error.	Sample XIV. Percentage of Decantation Error to Total Organisms Observed.	Sample XV. Organisms observed. By usual Method.	Sample XV. After Second Decantation or Decantation Error.	Sample XV. Percentage of Decantation Error to Total Organisms Observed.
Diatomaceæ,	91.0	14.0	13.3	153.0	7.0	4.4	82.0	1.0	1.2
Cyanophyceæ,	178.0	18.0	9.2	137.0	12.0	8.1	138.0	0	0
Algæ,	85.0	0	0	74.0	1.0	1.3	46.0	0	0
Fungi,	112.0	0	0	344.0	4.0	1.1	132.0	4.0	2.9
Rhizopoda,	7.0	2.0	22.2	10.0	1.0	9.1	2.0	0	0
Infusoria,	28.0	0	0	21.0	2.0	8.7	2.0	1.0	33.3
Vermes,	0	1.0	100.0	0	0	0	1.0	0	0
Other objects,	1.0	0	0	1.0	0	0	1.0	0	0
TOTAL ORGANISMS,	452.0	35.0	7.2	740.0	27.0	3.5	404.0	6.0	1.5

TABLE III. — *Concluded.*

GROUPS.	Sample XVI. Organisms observed. By usual Method.	Sample XVI. After Second Decantation or Decantation Error.	Sample XVI. Percentage of Decantation Error to Total Organisms Observed.	Sample XVII. Organisms observed. By usual Method.	Sample XVII. After Second Decantation or Decantation Error.	Sample XVII. Percentage of Decantation Error to Total Organisms Observed.	Sample XVIII. Organisms observed. By usual Method.	Sample XVIII. After Second Decantation or Decantation Error.	Sample XVIII. Percentage of Decantation Error to Total Organisms Observed.	Average Percentage of Decantation Error for Eighteen Samples.
Diatomaceæ,	140.0	15.0	9.7	5,053	668.0	11.7	6,222	1,112	15.2	10.58
Cyanophyceæ,	110.0	4.0	3.5	190	2.0	1.0	253	1	0.4	2.45
Algæ,	39.0	2.0	4.9	103	4.0	3.7	138	25	15.3	4.08
Fungi,	236.0	24.0	9.2	116	0	0	139	70	4.8	5.91
Rhizopoda,	6.0	1.0	14.3	9	0	0	4	0	0	8.09
Infusoria,	15.0	0	0	47	9.0	16.1	53	0	0	9.52
Vermes,	0	0	0	2	1.0	33.3	2	0	0	14.81
Other objects,	0	0	0	2	0	0	0	0	0	1.59
TOTAL ORGANISMS,	546.0	46.0	7.7	5,522	684.0	11.0	6,811	1,145	14.4	7.53

From the table it is seen that there is always an error for Diatomaceæ, since they occur in each of the 18 samples. Algæ, although present in all of the 18 cases, occur in the error column in 11 cases only. Cyanophyceæ were present in 17 cases but in the error column in 12 cases only. Fungi were present in all 18 cases and in the error column in 16 cases. Infusoria, Rhizopoda, Vermes and other objects were present in 17, 13, 11 and 12 cases respectively, but in the error column they were found in 9, 4, 4 and 1 cases respectively. From the table we can see at a glance where the decantation error chiefly falls. It is largely among the heavier organisms, such as Diatomaceæ, which is what we might expect, for diatoms, being coated with silicious shells, must have a greater specific gravity than Algæ and other forms. The error is probably due to the fact that some of these organisms settle quickly to the bottom of the test tube, with the sand, before they can be decanted with the supernatant liquid into the second test tube.

The percentages of the total error for all organisms obtained by averaging percentages are printed in the last column, and 7.53 per cent. is the average error due to failure in securing all the organisms when the first five cubic centimeters are decanted into the second test tube.

The decantation error may be partly overcome by allowing the decanted water containing the organisms to stand for a time until they have mostly settled to the bottom of the test tube, the clear portion of the liquid being then poured back into the first test tube and the sand thoroughly washed with it a second time. The error is an important one in spite of this precaution. I have tried other means of avoiding it but the resulting error is still considerable. Another way is to wash the sand a second time with five cubic centimeters of fresh distilled water, as in the experiments which have just been described, count as before, and add the results thus obtained to the first results. In practice this refinement is omitted because of the time required.

(3.) One of the most important parts of the method has thus far not been mentioned. This is the filter proper. A good filter cannot be made by pouring a quantity of sand, regardless of its size or condition, into a funnel. If the sand is too coarse, it will not detain the organisms ; if too fine, it will not settle to the bottom of the test tube much sooner than the organisms and much of it will be poured

over into the second test tube with them, thus nullifying one of the most important features of the method, *i. e.*, the getting rid of the sand. In the work of the Board, clean white quartz sand known as Berkshire is used.

In order to test the filtering efficiency of different sizes of this Berkshire sand a series of experiments was undertaken, the results of which are given in the following table. By "size of sand 40–60" is meant that size of sand which passes through a brass sieve having 40 meshes to the inch, but which does not pass through one having 60 meshes to the inch. The experiments were duplicated for each size of sand.

To make the experiment conclusive distilled water was used, to which had been added common yeast containing some starch grains. Yeast was used because its cells are smaller than any of the microscopical organisms found in Massachusetts drinking waters. If the sand retains yeast cells it is safe to conclude that it will retain larger forms as well. The number of cells which had passed through the sand filter was found by refiltering the effluent through the very finest sand (finer than 140) and examining by direct inspection of the sand, according to the original Sedgwick method. In this method a very small amount of sand is used, and, after filtration, sand and organisms are washed into the counting chamber where 20 fields are examined. (Report on the Biological Work of the Lawrence Experiment Station, *loc. cit.* page 806.)

The decantation error or error due to organisms remaining in the sand after decanting is determined as before, by washing the sand with a second five cubic centimeters of distilled water. The efficiency of the different sands is found by adding together the percentages of yeast or starch observed by the usual method, and the percentage of the decantation error.

TABLE IV.— *Showing the Filtering Efficiency of Different Sizes of Sand for Yeast Cells and Starch Grains.*

Number.	Size of Sand.		A.—Yeast Cells Observed. Number of Cells observed by Usual Method. Number in 1 Cubic Centimeter.	Percentage of Total Number observed.	Number of Cells observed after Second Decantation, or Decantation Error. Number in 1 Cubic Centimeter.	Percentage of Total Number observed.	Number of Cells observed after Second Filtration, and through Number 140 Sand. Number in 1 Cubic Centimeter.	Percentage of Total Number observed.	Total Number of Yeast Cells observed. Total Yeast in 1 Cubic Centimeter.	Filtering Efficiency. Efficiency of Filtration per cent. (Average A and B.)
1	A	40-60	8,900	65.5	1,760	12.9	2,928	21.6	13,588	78.40
	B	40-60	89,880	-	-	-	17,172	-	-	
2	A	60-80	87,560	76.28	17,560	15.30	9,664	8.42	114,784	91.28
	B	60-80	53,600	74.79	11,600	16.19	6,464	9.02	71,664	
3	A	80-100	44,280	81.26	6,580	12.08	3,632	6.66	54,492	94.90
	B	80-100	71,200	86.80	7,920	9.65	2,912	3.55	82,032	
4	A	60-120	33,200	71.47	11,620	25.02	1,632	3.51	46,452	96.70
	B	60-120	46,320	84.48	6,780	12.37	1,728	3.15	54,828	

TABLE IV — *Showing the Filtering Efficiency of Different Sizes of Sand for Yeast Cells and Starch Grains*— Concluded.

Number.	Size of Sand.		B.—Starch Grains Observed. Number of Grains observed by Usual Method. Number in 1 Cubic Centimeter.	Percentage of Total Number Observed.	Number of Grains observed after Second Decantation, or Decantation Error. Number in 1 Cubic Centimeter.	Percentage of Total Number Observed.	Number of Grains observed after Second Filtration, and through Number 140 Sand. Number in 1 Cubic Centimeter.	Percentage of Total Number Observed.	Total Number of Starch Grains observed. Total Starch Grains in 1 Cubic Centimeter.	Filtering Efficiency. Efficiency of Filtration per cent. (Average A and B.)
1	A	40-60	-	-	-	-	-	-	-	95.57
	B	40-60	1,250	-	-	-	58	4.43	1,300	
2	A	60-80	860	84.98	130	12.85	22	2.17	1,012	92.33
	B	60-80	1,740	79.09	170	7.73	290	13.18	2,200	
3	A	80-100	210	81.35	20	7.75	28	10.9	258	92.60
	B	80-100	700	87.7	70	8.8	28	3.5	798	
4	A	60-120	220	80.6	50	18.3	3	1.1	273	98.8
	B	60-120	460	91.7	35	6.9	7	1.4	502	

From this series it is seen that the efficiency increases as the size of sand diminishes, and that sand which passes through a sieve of 60 meshes to the inch but not through one with 120 meshes to the inch is the most efficient of those used. The efficiency for starch is greater (98.8 per cent. for the finest sand) and the difference between the sands for starch is not so marked as in the case of the yeast, because of the comparatively large size of starch grains. It will be noticed that the percentage of yeast observed by the usual method is greater for the sand 80–100 than for the sand 60–120, because of the large decantation error in the latter case (25 per cent. for yeast and 18 per cent. for starch). This decantation error remains otherwise about the same for all sizes of sand, and I am at a loss to account for the large percentage in this particular case. I have never been able to find as great an error from this cause with this sand at any other time; and Table III. shows that the average decantation error for total organisms is only 7.53 per cent. for the same size of sand which has been used since March 1, 1891. This 60–120 sand is composed of sand of different sizes, in the following proportions: 60–80, 39 per cent. by weight; 80–100, 34 per cent; and 100–120, 27 per cent.

A Comparison of Two Different Portions of the Same Water examined successively by the Sedgwick-Rafter Method.

A valuable and practical test of the method consists in the comparison of the results of examinations of two different cubic centimeters out of the five, and also of two different portions of the same water under precisely the same conditions.

The following experiment was undertaken for the purpose of comparing the results of separate examinations of two cubic centimeters of the five. The two portions were withdrawn from the test tube one after the other and examined. The results are shown in the following table, in which the figures represent the number of organisms in one cubic centimeter of the original sample.

TABLE V. — *Showing the Variation in Numbers of Organisms Observed in Two Different Cubic Centimeters out of the Five.*

Groups.	Sample I.		Sample II.		Sample III.	
	First Cubic Centimeter.	Second Cubic Centimeter.	First Cubic Centimeter.	Second Cubic Centimeter.	First Cubic Centimeter.	Second Cubic Centimeter.
Diatomaceæ,	218.0	216.0	106.0	83.0	186.5	175.5
Cyanophyceæ,	195.5	210.5	14.5	29.5	200.5	204.5
Algæ,	135.5	124.5	81.5	93.5	129.0	144.5
Fungi,	69.5	79.5	0	0	69.5	93.5
Rhizopoda,	5.0	0	0	0	0.5	0
Infusoria,	9.0	8.0	0	0	10.0	9.5
Vermes,	0.0	1.0	0	0	0	0
Total Organisms,	628.0	639.5	202.0	206.0	596.0	627.5

These portions were examined independently of each other and the results were not known until this entire investigation was completed. It will be noticed that the totals are higher for the second cubic centimeter examined, in every case. This increase in totals may probably be explained as follows: the one cubic centimeter taken for examination is usually withdrawn from about midway between top and bottom of the five cubic centimeters of decanted liquid after this has been thoroughly shaken. In the time elapsing between shaking and the withdrawal of the one cubic centimeter for examination, the organisms settle more or less, giving a certain concentration of organisms in the four cubic centimeters remaining in the test tube.

The following experiment was undertaken for the purpose of comparing the results of examinations of two separate portions of the same water. Two equal portions were taken from the same bottle and allowed to filter through equal depths of similar sand. The experiments were made by the same observer upon five different waters and the results are given in table VI.

TABLE VI. — *Results of Examination of Two Equal Portions of the Same Waters.*

		Sample I.		Sample II.		Sample III.		Sample IV.		Sample V.	
		First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.
Diatomaceæ.	Asterionella,	2	0	1	1	34.5	49.0	2,056	2,476	5.0	7.0
	Cyclotella,	0	0	0	0	0	0	226	234	9.5	8.5
	Diatoma,	0	0	0	0	0	0	0	0	0	0
	Epithemia,	0	0	0	0	0	0	0	0	0	.5
	Fragilaria,	4	0	0	0	20.0	0	0	0	3.0	2.0
	Gomphonema,	0	0	0	0	0	0	0	0	0	0
	Grammatophora,	0	0	0	0	0	0	0	0	0	0
	Melosira,	0	0	0	0	60.5	66.0	14	0	160.0	121.0
	Meridion,	0	0	0	0	.5	.5	1	0	0	0
	Navicula,	6	5	1	1	0	0	3	3	.5	.5
	Nitzschia,	0	0	0	0	0	0	0	0	0	0
	Pinnularia,	0	0	0	0	0	0	0	0	0	0
	Stephanodiscus,	0	1	0	0	5.5	5.0	0	0	21.5	26.5
	Synedra,	1	2	3	2	1.0	1.0	3	27	5.0	9.5
	Tabellaria,	0	1	25	27	4.5	.5	2,750	3,482	13.5	11.0
Cyanophyceæ.	Anabæna,	108	78	10	11	6.0	2.0	32	8	0	0
	Aphanocapsa,	0	0	0	0	0	0	32	5	0	0
	Chroöcoccus,	4	0	0	0	0	0	70	156	10.0	5.0
	Clathrocystis,	30	46	0	0	0	0	5	10	2.0	.5
	Cœlosphærium,	1	2	0	0	0	0	1	0	4.5	9.0
	Microcystis,	66	50	0	0	0	0	50	74	179.0	186.0
	Nostoc,	90	148	0	0	0	0	0	0	0	0
Algæ.	Arthrodesmus,	0	0	0	0	0	0	1	0	0	0
	Botryococcus,	0	1	0	0	0	0	1	1	4.0	7.5
	Chlorococcus,	0	0	0	0	0	0	14	24	0	0
	Closterium,	56	60	0	0	0	0	0	0	120.0	113.0
	Conferva,	14	0	0	0	0	0	0	0	0	0
	Cosmarium,	1	0	0	0	0	0	1	0	0	0
	Hyalotheca,	0	2	0	0	0	0	0	0	0	0
	Pediastrum,	4	1	0	0	0	0	0	2	0	0
	Protococcus,	14	13	8	0	0	0	4	0	2.0	2.5
	Raphidium,	0	2	0	0	0	0	27	60	4.5	1.5
	Scenedesmus,	0	1	0	0	.5	.5	4	6	4.5	3.0
	Sorastrum,	1	1	0	0	0	0	0	0	.5	.5
	Staurastrum,	0	0	0	1	0	0	5	3	0	1.0
	Staurogenia,	0	0	0	0	0	0	46	42	0	0
	Volvox,	1	1	0	0	0	0	0	0	0	0
Fungi.	Beggiatoa,	0	0	0	0	0	0	0	0	0	0
	Crenothrix,	10	6	1	2	0	0	1	3	7.5	5.5
	Molds,	0	0	0	0	0	0	1	0	0	0
	Zoöglœa,	64	78	13	14	61.0	64.0	114	136	62.0	64.0
*	Actinophrys,	0	0	0	0	0	0	9	4	0	0
	Arcella,	5	1	0	0	0	0	0	0	.5	.5
Infusoria.	Ceratium,	0	0	0	0	0	0	0	0	1.0	1.5
	Codonella,	0	0	0	0	0	0	0	0	.5	3.0
	Dinobryon,	0	0	105	199	0	0	0	0	0	0
	Dinobryon Cases,	0	0	0	0	0	0	4	12	0	0
	Monas,	1	2	0	0	0	0	2	6	1.5	.5
	Peridinium,	2	2	2	0	0	0	86	33	0	0
	Peridinium Cases,	0	0	20	35	0	0	0	0	0	0
	Tintinnidium,	1	1	0	0	0	0	0	0	0	1.0
	Trachelomonas,	34	56	2	1	.5	1.5	0	2	4.5	8.0
	Uroglena,	1	0	0	0	0	0	0	0	0	0
	Vorticella,	0	0	0	0	0	0	5	0	1.5	0

* Rhizopoda.

TABLE VI. — *Concluded.*

		Sample I.		Sample II.		Sample III.		Sample IV.		Sample V.	
		First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.
Vermes.	Anurea,	0	0	0	0	0	0	2	0	0	0
	Asplanchna,	1	1	0	0	0	0	0	0	0	0
	Polyarthra,	0	0	0	0	0	0	0	1	0	0
	Rotatorian Ova,	0	0	0	0	0	0	0	1	0	0
Other Objects.	Entomostracan Ova,	1	1	0	0	0	0	0	0	0	0
	Other objects,	0	2	0	0	0	0	2	0	0	0
Number of Genera,		27	28	12	11	11	10	32	26	26	26
Total Organisms,		523	555	191	294	194.5	190.0	5,522	6,811	628.0	596.0

TABLE VI. — SUMMARY.

	Sample I.		Sample II.		Sample III.		Sample IV.		Sample V.	
	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.	First Portion.	Second Portion.
Diatomaceæ,	13	9	30	31	126.5	122.0	5,053	6,222	218.0	186.5
Cyanophyceæ,	299	324	10	11	6.0	2.0	190	253	195.5	200.5
Algæ,	91	72	8	1	.5	.5	103	138	135.5	129.0
Fungi,	74	84	14	16	61.0	64.0	116	139	69.5	69.5
Infusoria,	39	61	129	235	.5	1.5	47	53	9.0	10.0
Vermes,	1	1	0	0	0	0	2	2	0	0
Rhizopoda,	5	1	0	0	0	0	9	4	.5	.5
Other objects,	1	3	0	0	0	0	2	0	0	0
Number of Genera,	27	28	12	11	11	10	32	26	26	26
Total Organisms,	523	555	191	294	194.5	190.0	5,522	6,811	628.0	596.0
Percentage of Difference,	2.96		20.22		1.16		10.44		2.6	

Average Percentage of Difference, Five Samples, . . 7.47

The results of these two experiments illustrate the value which, in spite of its errors, this method has for comparative examinations of water. A glance at the summary shows that the totals for the different classes of organisms are as nearly alike as can be expected when we take into consideration the sources of error in preparing the sample. The numbers of genera correspond very closely, showing that for qualitative work also the method is excellent.

All experiments made during this investigation have been duplicated, step by step, by an assistant whose results corroborate the conclusions which have been drawn. The difference between the two sets in regard to numbers of organisms and genera, shows also the effect of the personal factor in enumeration.

I may further remark that certain perishable forms may sometimes fail to be detected by this method. This is especially true of delicate gelatinous organisms which disintegrate upon the sand immediately after they are stranded and left exposed to the air by the retreating water. Such are some *Volvocineæ*, certain Infusoria and possibly other organisms. A careful naked-eye or hand-lens examination of the original sample should therefore never be neglected. It is also possible that some delicate forms are also broken up by the agitation of the sand with the distilled water; and the distilled water itself may be unfavorable in some cases. Of these possibilities we have at present but very little exact knowledge.

In conclusion I may state that I have found no difficulty whatever in using this method. It reveals organisms in drinking water different from and often far more abundant than the bacteria in the same sample, and it may now be said with truth that in this method we have a means of detecting and enumerating the microscopical organisms in water, which is probably quite as accurate as the prevailing method of detecting and enumerating the bacteria.*

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* Since the above was written Mr. George W. Rafter, C. E., of Rochester, N. Y., has published an important treatise on "The Microscopical Examination of Potable Water," in which he describes the Sedgwick-Rafter method and discusses its applications. (Van Nostrand, New York, 1892.)

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

Nov. 1, 1889, to Dec. 31, 1891.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION, NOV. 1, 1889, TO DEC. 31, 1891.

The experimental work of the Lawrence Experiment Station is still under the active direction of Hiram F. Mills, C. E., member of the Board, who originally designed the station and planned its work. Mr. Allen Hazen is chemist in charge of the station, and Mr. George W. Fuller is in charge of the biological department. Mr. Harry W. Clark is assistant chemist. The compiling of the records and the preparation of the tables and diagrams have been the work of Mr. F. L. Fales. Professors T. M. Drown and W. T. Sedgwick of the Massachusetts Institute of Technology are respectively consulting chemist and biologist with a general oversight of the chemical and biological investigations.

The following detailed account of the work of the station has been prepared by Mr. Allen Hazen, chemist in charge:—

The special report of the board upon the Purification of Sewage and Water, 1890, contains a full account of the work at the Lawrence Experiment Station during the first two years up to Nov. 1, 1889, and also a summary of the results for 1890.

During the past two years investigations have been continued upon purification by filtration along the same general lines, but in such a way as to throw additional light upon numerous points of great practical importance. Most of the filters described in the previous report have been continued in use to obtain information as to their permanence, while many others have been started to investigate special points connected with sewage purification and the filtration of water.

Filter Tank No. 1, which is one of the original filters and has been in use four years, has filtered sewage during the past two years, 1890 and 1891, at an average rate of 85,920 gallons per acre daily for every day in that time, and with a removal of 94 per cent. of the organic matters, as shown by the albuminoid ammonia, and 98 per cent. of the bacteria. Filter Tank No. 2, also one of the inal filters, has filtered for the same period, at an average

49,360 gallons per acre daily, and has removed 97.5 per cent. of the organic matters and at least 99.99 per cent. of the bacteria of the applied sewage. With many other filters correspondingly good results have been obtained.

The purity of the effluents obtained by intermittent filtration was thoroughly discussed in the report on the Purification of Sewage and Water, and it will suffice to say in this connection that there is no other method of sewage purification which yields results at all comparable to those obtained by intermittent filtration under favorable conditions.

One of the most important results of the past two years' work is the fact that, by systematically breaking the scum which forms on the surface of filters, a very much larger quantity of sewage can be purified without any deterioration in the quality of the effluent.

We had found that different materials require different treatments for the best results; that a system of applying sewage best adapted to a fine material fails to yield the best results when applied to a coarse sand, and *vice versa*. By studying the performance of our different filters under various conditions, in connection with the mechanical composition of their materials, we have discovered many of the causes of these differences, and have secured data which will enable us to determine, in advance, the general line of treatment required by different sands. In a similar way we can form an approximate estimate of the quantity of sewage which can be successfully applied to various materials under known conditions.*

We have continued the study of the effect of winter weather upon filtration, and have found that even with unprotected filters good results are possible in our climate under some conditions to be discussed in the following pages. The effluents obtained in winter, while less perfect than those of the warmer months, were still good, — much better than could be obtained by other processes, as, for instance, chemical precipitation.

An excessive quantity of acid in the sewage prevents satisfactory purification, but our experiments have shown that if, for the treatment of such sewage, a filter containing limestone is employed, the acid is neutralized, and a good result is obtained. This is a most important demonstration, as it assures the successful use of sewage

* The reader should bear in mind that the results given in this paper were obtained at the Experiment Station where all of the work is under scientific supervision, and the sewage is applied to small areas with uniformity and in definitely measured doses. In applying these results to actual work on the large scale some allowance may have to be made for less favorable conditions.

filters, regardless of possible acidity of sewage. If the sewage is only occasionally acid it will cause no trouble with ordinary filters, but if it upon trial proves to be so strongly and continuously acid as to prevent satisfactory purification, the addition of limestone to the upper layers can be depended upon to correct the acidity, and to insure as good a result as could otherwise be obtained from normal sewage.

The permanency of filters has also been made the subject of special study. The leading fact of intermittent filtration is that the organic matters of the sewage are destroyed instead of being stored in the filter, as is largely the case with other methods of filtration; and it seemed probable from the available data at the time of writing the special report upon the Purification of Sewage and Water, that there would be no continued accumulation of matter in the filter. Further study has shown, however, that the conditions which allow the purification of the maximum volume of sewage with the best results are such that a small percentage of the more stable organic matters of the sewage resist the oxidizing action of the filter, and accumulate in its upper layers, until after a time the surface may become choked to such an extent that it will remain saturated with water, thereby excluding the air. This can be remedied temporarily by turning the surface under, but it does not seem probable that continued inversion of the upper layers will allow the indefinite use of the same material while still maintaining the application of the maximum quantity of sewage. With lower rates of filtration the storage may be less in proportion to the amount of sewage, and, in any case, the replacing with fresh material of a moderate amount of the upper layers of sand from time to time will ensure the permanency of the filter. It is quite possible that the removed sand, when taken entirely away from the filter, will in time so far regain its original properties as to again allow its advantageous use as filtering material. We are giving much attention to methods for hastening this renovation.

The filtration of water also is receiving increased attention. The tables showing the work of the water filters for the time covered by this report are appended, together with a brief summary of the results obtained during 1892, up to the time of going to press. Owing to the important data bearing on this subject now being obtained, and as yet incomplete, a detailed discussion of these results is for the present postponed.

In the following pages are given tables representing the work

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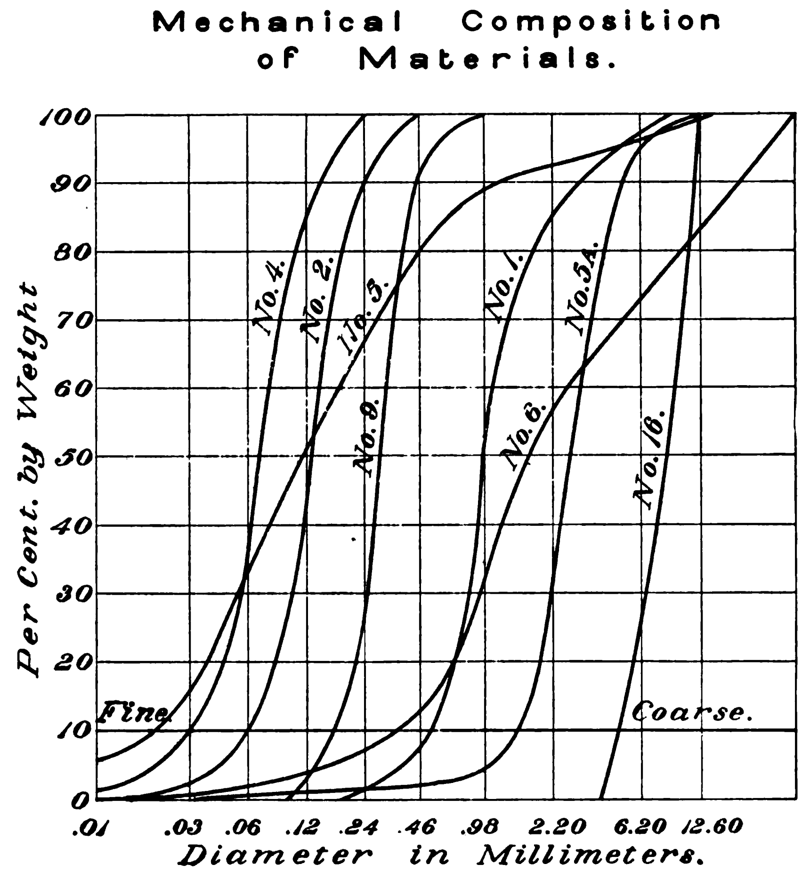
sizes of their particles give equally steep curves, regardless of the absolute sizes of the particles, thus greatly facilitating a comparison of different materials. This scale also shows adequately every grade of material from 0.01 to above 10 millimeters in a small space, and without unduly extending any portion of the scale. It is assumed



for the purpose of plotting that the particles of organic matter (determined by the loss due to heating that portion of the material finer than the 140 mesh sieve to a dull red heat) are less than 0.01 millimeters in diameter.

These materials may be said to include the whole range of sands available for sewage purification. Anything as fine as No. 5* is too

* For convenience the different materials are numbered to correspond with the filter tanks in which they were first used.

fine for advantageous use, while, at the other end, it would hardly be safe to depend upon a gravel coarser than No. 16 with a filtering stratum not over five or six feet in thickness.

With the mixed materials, Nos. 5 and 6, the smaller particles fill the spaces between the larger, and these finer portions determine the capillary attraction of the filter, its resistance to the passage of sewage, and, in fact, its action in every way. The appearance of No. 6 is coarser than No. 1, and the average size of its particles is greater, but its finest portion determines its character as a filter, so that it is practically finer than No. 1. It has been found as the result of a careful study that the points where the curves in the diagram cut the 10 per cent. line give the best idea of the total effect of the various materials. By measurements of the diagram we find that with the various materials 10 per cent. by weight of the particles are smaller than the sizes given in the following table. This gives as good an idea of the relative effective sizes of the materials as can be condensed into a single figure for each.

To obtain a definite basis of comparison of the uniformities of the sizes of the grains of different materials, the ratios between the diameters of the particles at the 10 per cent. line, as given above, and the diameters at the 60 per cent. line are given in the table under the heading "Uniformity Coefficient." If all the grains of a sand were absolutely of the same size, the coefficient would be 1; with a majority of our comparatively even-grained sands the coefficient ranges from 2 to 3; with No. 6 and No. 5, the figures are 8 and 9 respectively, and some extremely uneven sands have coefficients as high as 20 or 30, but our data in regard to the action of such materials is as yet very limited.

Size and Uniformity of Filtering Materials.

NUMBER OF FILTER.	Ten Per Cent. of Material Finer than (Millimeters.)	Uniformity Coefficient.	Albuminoid Ammonia. Parts per 100,000.
No. 5,	0.02	9.0	95.0
4,	0.03	2.3	18.0
2,	0.06	2.3	0.9
9,	0.17	2.0	0.7
6,	0.35	7.8	0.8
1,	0.48	2.4	0.4
5A,	1.40	2.4	0.5
16,	5.00	1.8	0.3

Air and Water Capacities of Materials when Drained.*

The average per cent. of sewage by volume which these materials hold, as they are in daily use for sewage filtration, at the time just before sewage is applied, that is, when they are as completely drained as is possible during regular use, is shown by the following diagram. The curves show the per cent. by volume of water retained at various depths in a bed five feet deep; the dotted lines indicate the total open space, and the distances between the curves and the corresponding dotted lines represent the amount of air.

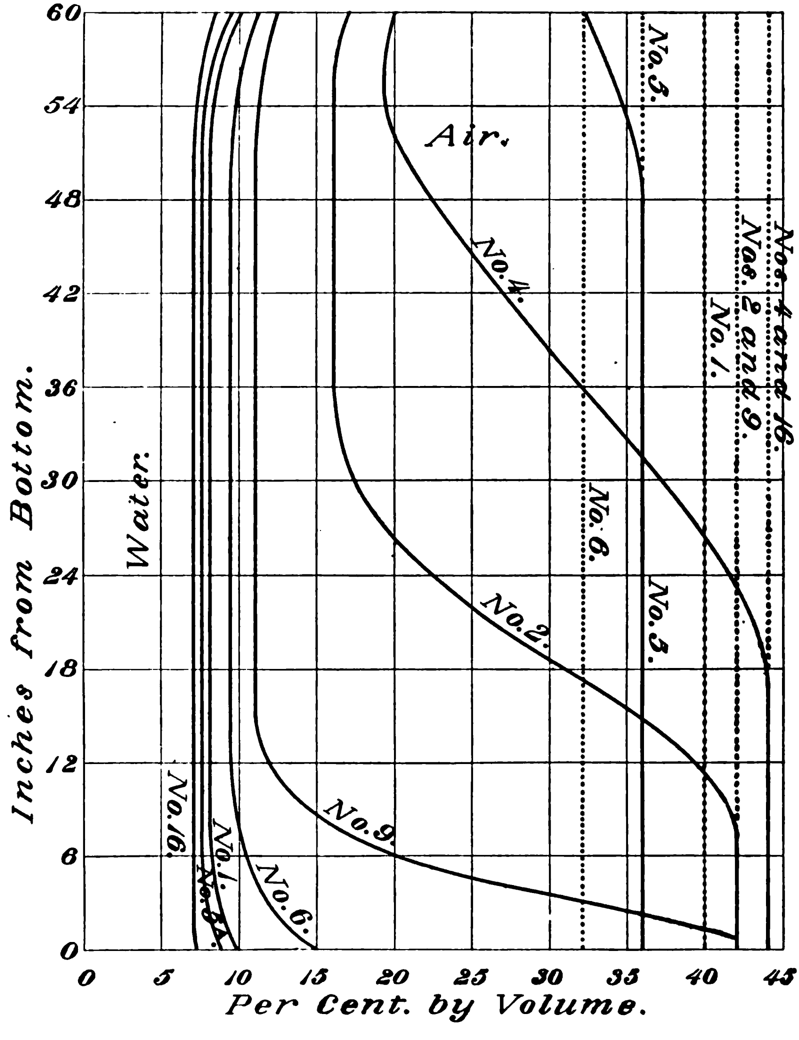
These curves showing the open space and the volume of water held when drained must be taken as general averages, under as nearly normal conditions as we have been able to obtain. The materials can be so packed as to contain either more or less open space than the figures given. The amount of water held depends not only upon the closeness with which the material is packed, but also upon its uniformity, — any stratification tending to increase in places the water capacity, — and also upon the amount of organic matter stored from the sewage. The curves give a correct idea of the general distribution of water and air in the various materials, but the daily variations, in addition to the above-mentioned differences, are so great that it is impossible to draw curves showing accurately the amounts under various conditions.

The amount of open space depends upon the shape and uniformity in size of the particles of sand, and is independent of their absolute size. The materials which have the sharpest rise on the diagram of mechanical composition (indicating greatest uniformity in size) have the greatest open space, while the sands having a more gradual rise pack more closely; the finer particles occupy the spaces between the larger stones, greatly reducing the open space.

While the total open space depends almost entirely upon the uniformity, and is independent of the absolute size, the amount of water held when drained depends very largely upon the size of the particles, the finer sands holding much water, especially at the bottom. With the coarser sands the percentage held is practically constant from top to bottom, with the exception of a few inches at each limit. The increase at the bottom is due to capillary attraction, and with the finer sands this acts for longer and longer distances, approxi-

* The term "water capacity" is used in this report to designate the amount of water retained in the interstices of the filtering material after it has been thoroughly drained.

Air and Water Capacities of Different Materials.



mately in inverse proportion to the square of the size of the sand particles, holding the material saturated, or nearly so, for 1 inch with No. 9; 10 inches with No. 2; 24 inches with No. 4, and 60 inches with No. 5. The increase at the top is due to the capillarity at that point being increased by the storage of organic matter from the sewage, and this portion of the curve depends entirely upon the amount of such material stored.

If the material was more than five feet deep above its drainage level, the water curves for the coarse materials would be lengthened by the insertion of a straight line above the curve due to capillarity as long as the increase in depth above five feet. The curve due to capillarity is constant from the bottom, and is independent of the depth of material. Thus, it has been found by experiment that if No. 2 sand was only a foot deep, that foot would hold the water shown by the lower foot on the diagram. In the same way the increase of water held by the organic matter at the top is independent of the depth of material.

The action of No. 4, and especially of No. 5, is influenced by the organic matters originally in these materials. This organic matter is best shown by the albuminoid ammonia given in the table (page 431). Its effect is to render the particles sticky, greatly increasing the capillarity, and consequently the water capacities, while the air space is correspondingly reduced. We have not as yet sufficient data to accurately formulate a general correction for organic matter. Organic matters from different sources will doubtless have different properties, and in different materials the same matter will probably have somewhat different effects. When coarse sands accumulate organic matters from sewage in their upper layers, the increase in water capacity is usually about one per cent. of water by volume for every three parts per 100,000 by weight of albuminoid ammonia. This ratio varies considerably in different cases, but any material containing organic matter will act as if it contained much more fine material than is indicated by its mechanical analysis.

Limitations of the Size of Single Doses of Sewage.

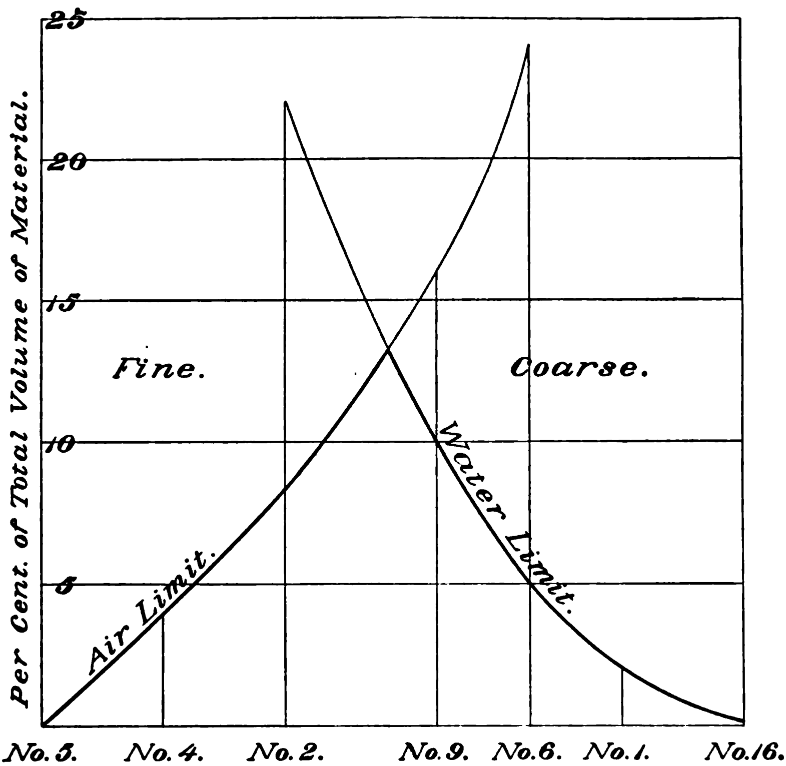
Each of the materials shown in the above diagrams has been made the subject of special study to determine the most advantageous method of applying sewage. With the coarser materials the amount of sewage which can be applied at one time is limited by the slight

retentive capacity of the sand; if too large a quantity is added at once a portion of the sewage will pass through the filter in too short a time for complete oxidation. It is evident that the dose should not exceed the water capacity of the material,—because if it should a portion would pass through at once after having forced out the water previously held. It has been shown in the special report upon Purification of Sewage and Water (page 672) that even an equivalent of the water capacity is too large a quantity to apply at once, for some of the sewage passes by the water previously held, which is mainly contained in the finer pores, while the larger open spaces offer a free passage to the freshly applied sewage. In the case of No. 1 sand, with a dose equal to two-thirds of the water capacity of the filter, a very considerable quantity of sewage passed unoxidized; with smaller doses, amounting to less than one-fourth of the water capacity, but applied so frequently that the total daily dose was even larger than before, a much better effluent was obtained. With the very coarse material, No. 16, the size of the dose which can be applied at once is very much smaller, even when compared with its smaller water capacity, some experiments having shown that with a dose of less than three per cent. of the water capacity a measurable, although a very small, amount of the freshly applied sewage reached the outlet within ten minutes. With the finer, No. 6, sand there is no trouble from sewage passing too quickly when the dose equals one-half the water capacity, or even somewhat more than half.

With the finer materials, the dose might be an even greater fraction of the greater water capacity, were it not for the limited air supply. It may be said, in a general way, that sewage requires its volume of air for its oxidation; and there is great danger that so much sewage may be got into the filter at once that the air present in the sand will prove inadequate for its purification. With No. 2 sand five feet deep and comparatively clean, a dose five inches deep over the surface has been applied three times a week without overtaxing the air; No. 4 has taken half as much with good results; while with the soil, No. 5, any practicable quantity is an overdose.

This limitation of the size of a single dose by the air and water capacities of the various materials is roughly illustrated by the following diagram:—

Limitation of Size of Single Dose by Air and Water Capacities.



If the amount of sewage applied at one time is greater than that indicated by the curve marked "Water limit," there is danger that some will pass the filter too soon for purification to have taken place, while if the quantity exceeds the "Air limit" there is danger that the oxygen in the filter will be exhausted before oxidation is complete. Taking the two curves together, the heavy line shows the maximum dose which can be applied at one time with good results.

Quantity of Sewage Applied to Different Materials.

The amount of sewage which can be applied in a single dose does not, however, give any indication of the amount of sewage which can be purified in a given time. With the fine materials

the sewage enters the sand slowly, and time must be allowed for this slow process, and afterwards for the water to drain out at the bottom, drawing in at the same time fresh air from the top to purify the next portion of sewage to be applied. Two or three days must be allowed for this to take place in sands as fine as Nos. 2 and 4, and probably a longer time might be advantageous under some conditions. With the coarser sands the draining and renewal of air is more rapid, and applications may follow each other at shorter intervals without danger of exhausting the air. The following table shows the doses which have been proved to be adapted to the various materials under the most favorable conditions of management, such as weekly raking of the surface and absolute uniformity and regularity in the application of sewage.

MATERIAL.	Diameter of Grain. Millimeters. 10 per cent. finer than, —	Depth of Material.	Size of Dose.		Number of Doses in One Week.	Average Amount Applied Daily. Gallons per Acre.
			Gallons per Acre.	Per cent. of Volume of Filter.		
No. 16, . . .	5.00	5 feet,	2,800	0.17	500	200,000
1, . . .	.48	5 "	40,000	2.45	18	103,000
6, . . .	.35	4 "	70,000	5.37	6	60,000
9, . . .	.17	5 "	120,000	7.36	6	103,000
2, . . .	.06	5 "	140,000	8.60	3	60,000
4, . . .	.03	5 "	80,000	4.91	3	34,000
5, . . .	.02	5 "	0	-	-	0

The smallness of the average amount applied daily on No. 6 is in part due to its less depth, four feet instead of five, and in part to the much smaller volume of its pores, owing to its being a mixed material containing particles having a wide range in their diameters. As has been said, any practicable dose on No. 5 is an overdose. It must be borne in mind that the above figures are only applicable to the comparatively clean materials, under the most favorable conditions, and that so large doses cannot be permanently applied with good results without renewing of the surface material, for reasons to be discussed under the heading "Permanency of Filters."

The question of greater or less depth of material is quite complicated, and we have as yet only limited data bearing on it. Some filters, Nos. 28, 29, 30 and 31, filled with No. 1 and No. 9 sands, thirty inches deep, have given excellent results with doses one-half as large as those used on five-foot filters. With the coarser sands it seems probable that, to a certain extent at least, the capacity to

purify sewage would be directly proportional to the depth. With the finer materials, the capacity depends to a greater extent upon the circulation of air through the upper layers, and this would not probably increase in direct proportion to the depth. An inspection of the diagram of air and water capacities (page 433) suggests, however, that with the finest materials, Nos. 4 and 5, a moderate increase in depth would increase their air capacity much more than in direct ratio to the increase in depth. A layer of No. 2 sand, twelve inches deep, or of No. 4 sand, two feet deep, would hold itself almost saturated with water, even when completely drained, and would be incapable of purifying sewage by oxidation. The depth of saturation of the material should be reckoned from the top of a layer of considerably coarser material, or from standing water.

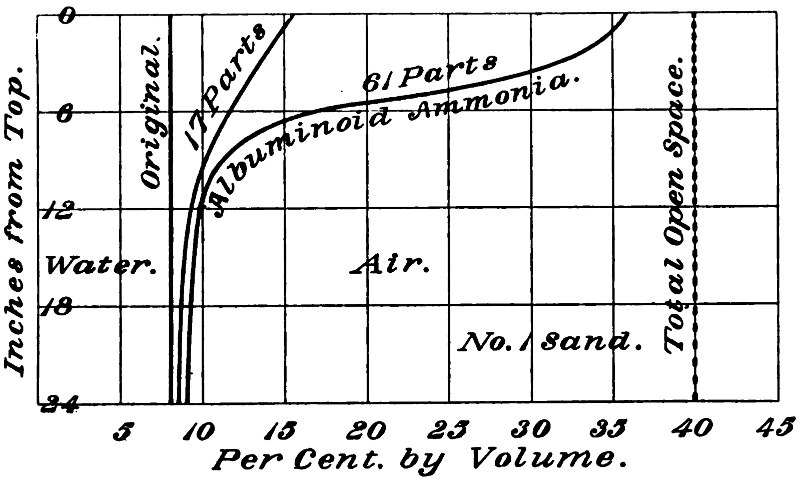
Effect of Continued Use.

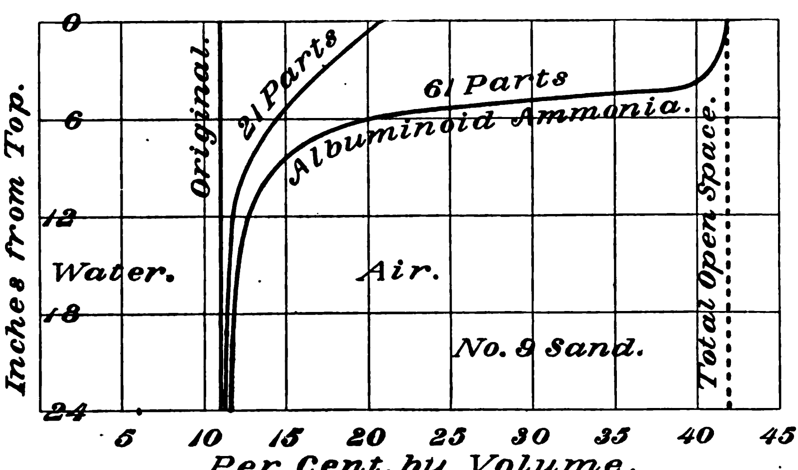
One effect of passing large volumes of sewage through clean sand is to increase the amount of organic matters held by the sand. This organic matter forms a sticky coating on the sand grains, as has already been noticed, and greatly increases the capillary attraction and water capacity, while the air space is correspondingly decreased. A most striking illustration of this is furnished by No. 1 sand in Filter 14. When the sand was new and quite clean, it retained only eight per cent. of water, but after three years of constant heavy dosing with sewage, every grain of sand in the upper portion of the filter was covered with a slimy coating, which, keeping itself moist, increased the water capacity of the entire filter to fourteen per cent., or nearly double the original amount.

With coarse materials, where the amount of sewage which can be applied at one time is limited by the water capacity, and a large excess of air is always present, this increase in the amount of water held has a beneficial effect, and the sand, after filtering sewage for a time, is capable of doing more and better work than at the beginning. With fine materials, on the other hand, where the amount of sewage which can be applied is limited by the air in the material, no such improvement with age is observed. The reduction of air space, especially near the surface where the storage of organic matter is greatest, retards the passage of sewage, and to an even greater extent the exchange of air, with the result that doses must be smaller, or else applied at longer intervals. The exclusion of air is not confined to fine materials; No. 6, No. 1, and even No. 16 become,

under some conditions, so clogged that it is the air capacity instead of the water capacity which limits them. The following diagrams

Water Capacity Increased by Storage of Organic Matters.





show how the water capacities were increased and the air capacities decreased in the upper layers of four filters by the storage of organic matter. The amount stored is indicated by figures on the curves, which represent the albuminoid ammonia in parts per 100,000 in the

upper six inches. The figures from which the diagrams were made will be given in a subsequent portion of this report under Filters 27, 28, 30 and 31.

As the water capacity line extends toward that showing the total open space, the nitrates in the effluent decrease, and finally, when the condition shown by the last line is reached, the upper layer remains saturated, or nearly so, thereby excluding air from the filter, and stopping purification. The accumulation of organic matters will be further considered under "Permanency of Filters."

As the sand becomes choked in its upper layers, the ventilation of the filter becomes of vital importance. The ridging of the surface of some of the filters was an attempt to secure better ventilation. It was hoped that as sewage passed down through the trenches, exhausted air would be driven up through the ridges, to be replaced by fresh air, as the filter drained. With Filters Nos. 2 and 9 no definite improvement followed the ridging. Filter No. 1 gave a better result after the change, but it is open to question whether this resulted from the ridges in themselves or from the reaching of cleaner sand by digging the trenches. In the latter case, the result might simply indicate that one-half the surface clean allowed better ventilation than the whole surface clogged. We have, then, no results which show any clear advantage from the use of trenches over flat surfaces, as far as ventilation is concerned.

Ventilation can often be increased by applying larger doses at longer intervals. A large dose of sewage makes a great disturbance of the air in a filter, and within certain limits, changes more air in proportion to its own volume than a smaller dose. The application of volumes of sewage in excess of the water limit in coarse materials causes a great increase in the number of bacteria in the effluent, but it may improve the chemical analysis when there is a lack of air, and so might be justified where there was no possibility of the effluent finding its way into drinking water.

Removal of Bacteria.

The removal of bacteria has a close relation to the size of the material. With the fine materials, Nos. 2, 4 and 5, there is reason to believe that no bacteria are able to pass from top to bottom of the filters; with the coarser No. 9 sand, if any pass, the number is ordinarily extremely small, certainly as low as one in a hundred thousand of those applied. The coarser sands, Nos. 1 and 6, allow

the passage of considerable numbers, especially with doses in excess of the water limit, and with the coarse gravels, bacteria come through freely and in large numbers, the percentage depending upon the condition of the filter and the size of the dose.

On the Effect of Frost.

During the first winter, 1887–88, the various filters were exposed to the weather without protection, and no nitrification was obtained until the temperature began to rise in spring. The result might have been different if the filters had been nitrifying well before cold weather. During the two following winters the filters were protected from snow, and to a certain extent from cold, by canvas covers. It was found that when the filters were so protected, almost, if not quite, as good results were obtained in the winter as during the warmer months, and it was established, as stated in the special report upon Purification of Sewage and Water (pages 29 and 255), that intermittent filtration is entirely practicable in this climate, if snow is kept from the filtering area.

We had no satisfactory information, however, as to what results could be obtained from unprotected filters. Accordingly, in the winter of 1890–91 the outdoor filters were left exposed to the weather. Filters 1, 2, 4 and 6 were receiving from 34,000 to 103,000 gallons of sewage per acre daily, and were free from complications, so that they furnish the best data in regard to frost. All the other filters with exposed surfaces were so complicated by other circumstances that the results obtained with them cannot fairly be considered in this connection.

Care of the Filters in Winter.

When sand is frozen solidly after draining there still remain open pores through which the sewage easily finds its way, thawing to some extent the frost as it proceeds. After the sewage has drained away, the portion which remains in the sand again freezes, but open pores are still left which allow the passage of the next portion of sewage. If, however, the sewage settles away very slowly, it will freeze before the sand drains, and in this case no pores are left, and the next application of sewage will remain upon the surface and freeze solidly, if the weather is cold enough. If snow is upon the surface of the sand and sewage is applied uniformly to it, it is at once chilled to the freezing point, and has then no power of thawing the frost in the upper layers of sand, and if the weather is cold the

whole will solidify on the surface, effectually closing the filter. The two essential conditions to the passage of sewage through the filters in winter are that sewage shall never be put into snow, and that the filtering material shall be open enough to absorb its dose rapidly.*

Sewage was applied uniformly at a temperature of from 44° to 46°, or the average sewer temperature in winter. The sewage which comes to the station is chilled by passing through the Merrimack River in an iron pipe, and is afterwards warmed to its original temperature by hot-water pipes passing through the measuring basins. All snow was promptly removed from the filters by shovels. Each week the surface was disturbed; if the sand became sufficiently thawed at any time when it was not sewage covered, it was then raked. When there was no such opportunity for raking, the surface was disturbed with a pick in numerous places. During December no record was kept of the exact time required for this work on the several filters; it was about the same as for January. For January, February and March it was as follows, in hours' work for one man on one two-hundredth of an acre: —

Filter.	January.	February.	March.
No. 1,	9	3	3
2,	7	3	3
4,	4	1½	1½
6,	4½	3½	2½

The full amount of sewage was applied throughout the winter, and nearly all passed the filters, as is shown by the following table: —

	Filter No. 1. Gallons per Acre Daily.		Filter No. 2. Gallons per Acre Daily.		Filter No. 4. Gallons per Acre Daily.		Filter No. 6. Gallons per Acre Daily.	
	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.
1890.								
November,	100,000	100,600	56,000	54,200	32,000	31,000	60,700	65,400
December,	100,600	95,600	56,800	41,200	36,100	32,000	54,600	52,200
1891.								
January,	100,600	102,800	54,200	55,800	20,700	26,000	63,200	63,600
February,	102,800	102,200	60,000	59,400	34,300	39,200	57,500	56,300
March,	81,300	81,100	45,100	42,800	25,800	31,600	38,400	37,900
Average,	97,060	96,460	54,420	50,680	29,780	31,960	54,880	55,080

* It should be said that with the conditions which obtain in actual practice with regard to the method of applying sewage, no serious difficulty has been experienced in Massachusetts in disposing of sewage in winter on porous ground.

In March the water in the river rose so high that filtration was stopped for some days, and this accounts for the smaller quantities in that month.

Results.

As soon as frost began to form freely in the various filters a marked change was noticed in the chemical composition of the effluents; the free ammonia increased, and soon the nitrates decreased. The organic matters, as shown by the albuminoid ammonia and by the oxygen consumed from permanganate, also increased, but not to an extent corresponding with the free ammonia. During the colder months nitrification was much checked; ammonia, instead of nitrates, was largely the end product of the oxidation, as far as nitrogen was concerned. The first stage of purification, namely, the oxidation to ammonia and carbonic acid, was not affected to the same extent.

The following table shows the average amount of albuminoid ammonia by months in the applied sewage and in the effluents of the filters under consideration in the order of fineness of material, No. 1 being very coarse sand, No. 6 coarse sand, No. 2 fine sand and No. 4 very fine sand: —

[Parts per 100,000.]

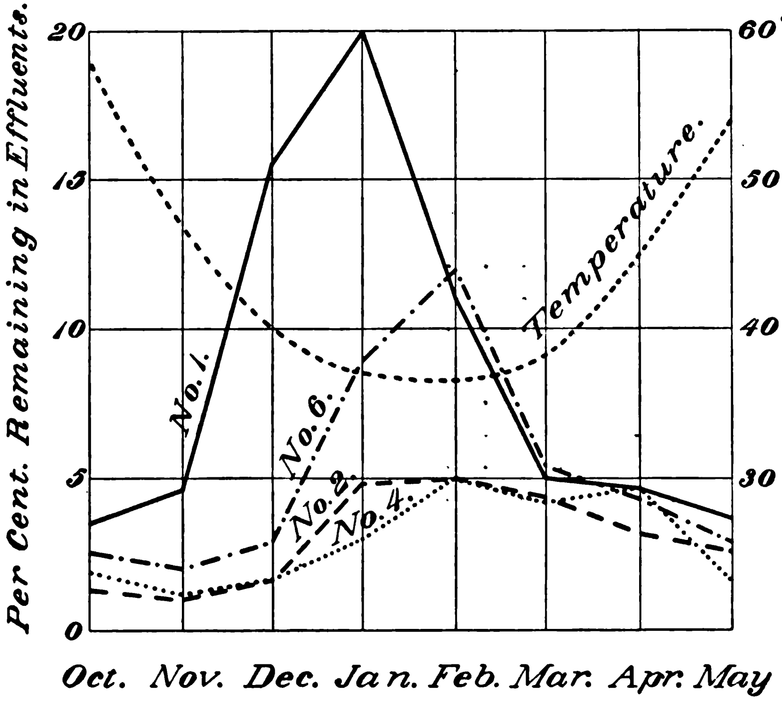
	Average Temperature of Effluents. — Deg. Fahr.	Average Albuminoid Ammonia.				
		Sewage.	No. 1.	No. 6.	No. 2.	No. 4.
1890.						
October,	58	.6183	.0217	.0160	.0079	.0120
November,	47	.9013	.0415	.0188	.0089	.0104
December,	40	.7117	.1105	.0206	.0124	.0121
1891.						
January,	37	.5033	.1022	.0449	.0242	.0153
February,	36.5	.4669	.0516	.0564	.0237	.0234
March,	38	.6258	.0816	.0340	.0275	.0270
April,	45	.4947	.0233	.0217	.0160	.0235
May,	54	.7017	.0257	.0206	.0240	.0120

Putting these figures in the form of percentages of organic matters remaining in the effluent we have: —

	Average Temperature of Effluents. — Deg. Fahr.	Per Cent. of Organic Matter Remaining.			
		No. 1.	No. 6.	No. 2.	No. 4.
1890.					
October,	58	3.5	2.6	1.3	1.9
November,	47	4.6	2.1	1.0	1.2
December,	40	15.5	2.9	1.7	1.7
1891.					
January,	37	20.0	8.9	4.8	3.0
February,	36.5	11.0	12.0	5.0	5.0
March,	38	5.0	5.4	4.4	4.3
April,	45	4.7	4.4	3.2	4.7
May,	54	3.7	2.9	2.7	1.7

These figures are also shown graphically by the accompanying diagram: —

Increase of Albuminoid Ammonia in Effluents, Due to Cold.

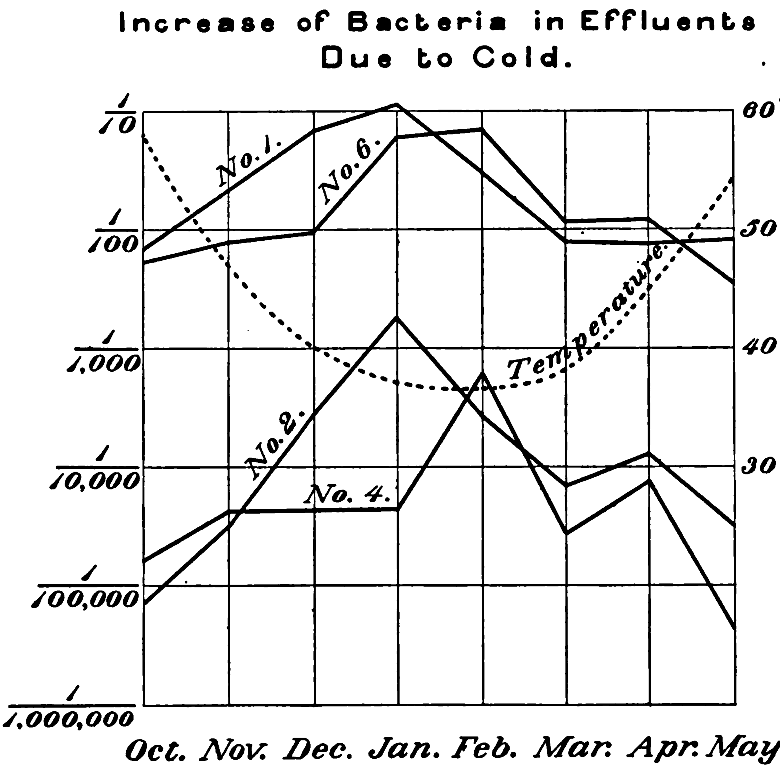


During the colder months of the year there was a period with each filter of about three months, during which purification was much less complete than at higher temperatures. The time of this period varied in the different cases: the coarse materials were the first to suffer; the finer sands were not so soon affected, but the period was as long, extending into warmer weather. With No. 1 a marked improvement occurred while the temperature of the effluent was still decreasing. With Nos. 2 and 6 the highest organic matter was coincident with the lowest temperature, while No. 4 followed some weeks later. During December the frost was particularly troublesome in Filter No. 1, and the distribution of sewage was imperfect, most of it going down through limited unfrozen areas. Later the frost was broken with picks, and better distribution was obtained. This explains probably, in a large measure, why the worst results were obtained so early in the season. It is also possible that the filter became in some way adapted to the frost; that, after a few weeks of use, the portions of the filter below the frost did their work more thoroughly than at first, regardless of temperature, for the same reason that any filter gives its best result after it has been used for a time.

The average numbers of bacteria per cubic centimeter by months were as follows: —

Month.	Temperature. Degrees Fahr.	Sewage. Bacteria.	Filter No. 1. Bacteria.	Filter No. 1. Per Cent.	Filter No. 6. Bacteria.	Filter No. 6. Per Cent.	Filter No. 2. Bacteria.	Filter No. 2. Per Cent.	Filter No. 4. Bacteria.	Filter No. 4. Per Cent.
1890.										
October,	58	2,487,000	16,000	.64	13,000	.52	17	.0007	39	.0016
November,	47	1,157,700	24,000	2.07	9,000	.78	36	.0031	45	.0040
December,	40	874,400	58,000	6.60	8,400	.96	284	.0280	35	.0040
1891.										
January,	37	456,000	51,000	11.20	27,000	5.90	822	.1800	19	.0042
February,	36.5	301,000	9,000	3.00	20,000	6.70	78	.0260	179	.0590
March,	38	563,000	4,400	.78	6,000	1.10	37	.0066	15	.0026
April,	45	375,000	2,900	.77	4,500	1.20	50	.0130	28	.0074
May,	54	1,370,000	11,000	.80	4,700	.34	44	.0032	6	.0004

The percentages are shown graphically in the accompanying diagram: —



The albuminoid ammonia and bacteria in the effluents in percentages of those in the sewage for the worst month, worst three months, and for a period in warm weather as nearly as possible comparable, are as follows: —

	Filter No. 1.		Filter No. 6.		Filter No. 2.		Filter No. 4.	
	Albuminoid Ammonia.	Bacteria.	Albuminoid Ammonia.	Bacteria.	Albuminoid Ammonia.	Bacteria.	Albuminoid Ammonia.	Bacteria.
Worst month,	20.0	11.20	12.0	6.70	5.0	.18	5.0	.059
Worst three months,	15.5	7.30	8.8	4.60	4.7	.078	4.7	.022
Warm weather,	5.0	1.20	2.6	.77	1.6	.003	1.5	.008
Ratio, warm weather to worst three months,	3.1	6.	3.3	6.	2.9	26.	3.1	3.

With the sub-surface application of sewage on Filter No. 7, which has a distributing pipe eighteen inches below the surface, no bad effects from cold weather have been observed. The effluent during the months January to July, 1891, was not of as good a quality as at other times, but it is believed that this was due entirely to over-dosing, and not to the temperature. This view is confirmed by the results during the succeeding winter, when, with a smaller dose, uniformly good purification was obtained, and the fluctuation in the free ammonia bore no relation to the weather.

To resume: We have found that frost checks both purification and nitrification, although the removal of the organic matter is more complete than the oxidation of ammonia. The principal disturbance from cold weather did not last more than three months, although nitrification was more or less incomplete for a longer period. During those three months the effluents from the different filters contained, in each case, about three times as large a proportion of the organic matters of the applied sewage as the effluents from the same filters contained under comparable conditions in warmer months.

During the winter months the filters removed: —

FILTER.	Albuminoid Ammonia.	Bacteria.
	Per Cent.	Per Cent.
No. 1, very coarse sand,	84	93
6, coarse sand,	92	95
2, fine sand,	95	99.92
4, very fine sand,	95	99.98

These results are good, although less perfect than those obtained in the warmer months. With the fine materials the purification is most complete, but even with the coarsest, No. 1, the result is far better than could be obtained by any process of chemical precipitation.

On the Treatment of Acid Sewage.

It was shown in the special report upon the Purification of Sewage and Water, that a long-continued application of acid sewage on Filter 15 A gave very unsatisfactory nitrification, although fair purification was obtained. In this case the final product of the oxidation of the nitrogenous organic matters was ammonia instead of nitrates. The effect of acid is quite similar to the effect of frost; both tend to prevent nitrification, and check, but do not entirely prevent, the oxidation of organic matter.

With our ordinary filters and normal sewage the effluents are very slightly alkaline, and the degree of alkalinity is extremely constant. It seems probable that any temporary excess of alkali is stored in the sand for the time, so that the filters have constantly on hand a small extra stock of base to meet any unusual activity in nitrification. We have found, for instance, that when air is excluded, or for some other reason, wide fluctuations in the nitrates occur within a short time, there is no corresponding variation in the alkalinity, but that the lime in the effluent varies with the nitrates. We can best account for this by supposing that there is storage and removal of base as the activity of nitrification requires.

Taking this view of the operation of filters, the temporary application of acid sewage should not be followed by bad results. The filter would probably be able to neutralize a moderate amount of acid for a short time, and nitrification would be uninterrupted. This was what happened when acid sewage was first put upon Filter 15 A.

The sands used in the filters contain almost no lime or available alkali, and if the application of acid sewage is long continued the small amount of stored base is exhausted, and nitrification is stopped and purification checked. It would, of course, be possible to neutralize acid sewage with lime before filtration, but this would involve expense and much trouble.

In Filter No. 17 A a little limestone was mixed with the upper layers of the filtering material, and sewage which was made strongly acid was regularly applied for over a year. The effluent showed as good a purification and nitrification as when normal sewage was filtered, under similar conditions, through sand without limestone. We have thus a cheap and effective remedy for any complication

due to acidity of sewage. If the sewage is only occasionally acid, or if the filtering material contains available base, the acid will not injuriously affect the result. If, however, the filtering material contains no lime, and the sewage is so constantly and strongly acid as to interfere with the result, a little limestone, put upon the surface or dug into the upper layers of the filter, will completely overcome the effect of the acid.

PERMANENCY OF FILTERS.

Some of our filters have been in continuous use, without change of material, for four years, and are still capable of doing good work. As has been frequently intimated on the preceding pages, there has been an accumulation of organic matters in these filters. We have already seen some of the effects of this accumulation in making the sands act as if they were finer than when clean, increasing the water capacity and decreasing the air space, thus within certain limits increasing the effectiveness of coarse materials, but not improving the fine sands. We have now to consider this accumulation in connection with the permanency of the filters.

During the first year's work Filter No. 1 stored 26 per cent. of the total nitrogen applied, and during the second year the increase in stored material was only 8 per cent. of the applied nitrogen. The storage was not evenly distributed throughout the year but was greatest during the winter months. In the spring and early summer some of the organic matter previously stored was oxidized. Filter No. 2 behaved in a similar way. It was quite natural to infer that in succeeding years the percentage of organic matter stored would be still further decreased, until at last a condition of equilibrium would be reached when removal by oxidation would equal the fresh storage. The data were inadequate, however, to justify definite conclusions on this point.

During the past two years we have obtained much additional information on this subject. The observations upon Filters 1, 2 and 6 have been continued, and we have, in addition, results from Filters 9, 14, 27, 28, 30 and 31. The following table contains a summary of our data in regard to the storage of organic matters. In it are shown, first, the total nitrogen applied and the amount stored in the various filters; next, the albuminoid ammonia applied and stored are compared, and, finally in the last columns, is shown the insoluble

albuminoid ammonia of the sewage, that is, that derived from the sludge, in comparison with that stored. The data from which this table has been made will be given in a subsequent portion of this report under the heads of the various filters.

Storage of Nitrogen by Filters.

	Time.	Nitrogen in Pounds as—								
		Total Nitrogen.			Albuminoid Ammonia.			Insoluble Albuminoid Ammonia.		
		Applied.	Stored.	Per Cent.	Applied.	Stored.	Per Cent.	Applied.	Stored.	Per Cent.
Filter No. 1, first year, . .	11 months,	16.62	4.27	26	8.14	4.27	52	6.46	4.27	66
" second year, .	11 months,	19.01	1.54	8	7.00	1.54	22	3.46	1.54	45
" third year, . .	13 months,	27.42	4.29	16	11.46	4.29	37	4.88	4.29	88
" fourth year, .	11 months,	41.42	5.90	14	16.57	5.90	36	8.57	5.90	69
" whole time, .	4 years, .	104.47	16.00	15	43.17	16.00	37	23.37	16.00	68
Filter No. 2, first year, . .	11 months,	7.88	2.94	37	3.80	2.94	77	3.10	2.94	95
" second year, .	11 months,	8.54	1.66	19	3.10	1.66	53	1.60	1.66	103
" third year, . .	17 months,	26.41	3.47	13	10.80	3.47	32	4.70	3.47	74
" fourth year, .	7 months,	15.43	1.54	10	6.17	1.54	25	3.12	1.54	49
" whole time, .	4 years, .	58.26	9.61	16	23.87	9.61	40	12.52	9.61	76
Filter No. 6, whole time, .	4 years, .	66.00	11.84	18	27.30	11.84	43	14.70	11.84	80
Filter No. 9, whole time, .	1 year, .	38.55	8.39	22	15.42	8.39	54	7.79	8.39	108
Filter No. 14, whole time, .	3½ years, .	1.3819	.1779	13	.5784	.1779	31	.3185	.1779	56
Filter No. 27, whole time, .	1½ years, .	.3049	.0853	28	.1620	.0853	53	.1160	.0853	73
Filter No. 28, whole time, .	1½ years, .	.3049	.0763	25	.1620	.0763	47	.1160	.0763	66
Filter No. 30, whole time, .	1½ years, .	.2149	.0294	14	.0849	.0294	35	.0402	.0294	74
Filter No. 31, whole time, .	1½ years, .	.2123	.0272	13	.0837	.0272	32	.0397	.0272	68

It must not be supposed that all the clogging is due to the nitrogenous matters represented by the albuminoid ammonia. On the contrary, fats and other non-nitrogenous bodies are known to be stored, and doubtless play their part in the clogging; nevertheless, the albuminoid ammonia furnishes a convenient and fairly satisfactory index of the extent of clogging, and the amount of organic matter stored.

The relative proportions of nitrogen in different forms in Lawrence

sewage, as shown by hundreds of analyses extending over four years, are as follows: —

	Per Cent.
Nitrogen as free ammonia, ...	58.3
Nitrogen as soluble albuminoid ammonia, ...	18.5
Nitrogen as insoluble albuminoid ammonia, ...	23.2
	100.0

Of the nitrogen stored in the filters more than 98 per cent. is in the form of insoluble albuminoid ammonia, so that it would seem that the insoluble organic matters are mainly responsible for the clogging of the filters. It is of course possible that some of the soluble organic matters should become insoluble in the filter. Under some conditions this is known to take place, as, for instance, when the storage is greater than the total amount of the insoluble matter applied. This has only happened under conditions unfavorable for oxidation, as for instance during winter, and as soon as the conditions became more favorable, some of the stored material was removed.

In order to test the effect of filtering sewage containing more than the normal amount of insoluble matter, small filters, Nos. 27 and 28, were treated with sludge separated from sewage by sedimentation. Corresponding filters Nos. 30 and 31 were treated with normal sewage.

The results obtained are as follows: —

	Insoluble Nitrogen Applied.	Nitrogen Stored.	Per Cent.
Tank 30, No. 1 sand, normal sewage, ...	.0402	.0294	74.2
Tank 27, No. 1 sand, concentrated sewage, ...	.1160	.0853	73.5
Tank 31, No. 9 sand, normal sewage, ...	.0397	.0272	68.5
Tank 28, No. 9 sand, concentrated sewage, ...	.1160	.0763	65.8

In each case there is increased storage with concentrated sewage, and the increase is directly proportional to the sludge added.

Turning to our other filters we find that No. 1 has stored 68 per cent. of the albuminoid ammonia of the applied sludge; No. 2, 76 per cent.; No. 6, 80 per cent.; No. 9, 108 * per cent.; No. 14, 56

* The excessive storage in No. 9 may be the result of the application of sewage containing more sludge than that applied to the other filters. The chlorine in the effluent from this tank has averaged considerably higher than that of the sewage and of other tanks, and it seems probable that the sewage, always pumped at the same hour in the morning for this filter, may have been somewhat stronger, and that for other filters slightly less concentrated than that represented by the average sewage samples.

per cent., averaging for all the filters for which we have accurate results, 74 per cent. The lowest figure obtained is with Filter 14 (No. 1 sand), on which sewage has always been applied in large doses, and only once a day. Filter 1 for the first two years gave almost the same percentage storage with a similar treatment. During the last two years sewage has been applied in smaller doses three times a day. This treatment has given a better effluent, but the storage has also been greater. The filters having the greatest storage (Nos. 9, 6 and 2) are the finer sands, and these have suffered at times from incomplete ventilation; and it seems probable that this has been one of the factors in the increased storage.

The constancy of the percentages of storage of insoluble nitrogenous matters is remarkable. Taking the final results, the highest are not twice as great as the lowest, and with seven filters out of nine the percentages are between 66 and 80. This can only be interpreted as showing that there are substances in sewage so stable as to resist, for a very long time at least, the oxidizing action of the filters.

We have not as yet obtained a permanent condition of equilibrium with no further increase in storage. On the contrary, the organic matters have been steadily increasing, and at a rate approximately equal to 70 per cent. of the insoluble matters applied. This accumulation has now proceeded so far in some of our filters as to seriously cripple them. To secure as good results in the future as in the past some remedy must be applied. Two alternatives suggest themselves: the clogged upper layers can be turned under to a considerable depth, or they can be removed. If upon turning the surface under, its organic matters become oxidized in time so that it will again serve for a surface layer, then turning under is the better policy; otherwise removal is the better way.

This point was discussed in the report upon the Purification of Sewage and Water, pages 44 and 237. It was there shown that the organic matters were accumulating at the surface and decreasing elsewhere, and it was thought that this indicated a stronger oxidizing action beneath the surface. Another explanation is that the matters near the surface were those suspended in the sewage and that those stored below were the more soluble and decomposable matters of the sewage; that it was the difference in character and not in position, which determined their oxidation. This view is supported by the fact that when the surface was raked and spaded under,

these matters instead of disappearing steadily increased, as more sewage was applied.

Some results on this point have also been obtained with Filter No. 14. On July 29, 1891, the upper foot of material in this tank was inverted. Excellent results followed, and after three months the albuminoid ammonia was reduced in the second six inches, that is, in the old surface, from 50 to 29 parts per 100,000. At the same time there was an increase nearer the surface almost equal to the suspended matter of the applied sewage, and also in the material below the first foot. This last amounted to more than half as much in total weight as the decrease in the old surface layer. After making the inversion, the downward flow of sewage was very rapid after flooding; and it is probable that this organic matter was carried down mechanically by the rapid current. The total reduction of albuminoid ammonia below the upper six inches was comparatively small.

The fact of continually increasing storage in the large out-door filters is sufficient evidence that they do not afford conditions favorable to the oxidation of this material. On them we have applied as much sewage as was possible with good results, and much more than is usually applied in practice. In a majority of cases, — always with the fine materials, and often with the coarser ones, — this has meant as much sewage as could be oxidized by the air in the filter. All the air available has been required to oxidize the more decomposable matters; the more stable insoluble matter, we may believe, can only receive the attention of the bacteria when there is an excess of air. Filters do their maximum work when the volume of sewage applied is so large that there is no considerable excess of air; when the supply exactly meets the present demand, oxidizing only the less stable matters and preventing their passage into the effluent. There may also be a question as to whether the bacteria will do their best work upon this insoluble matter while they are receiving a daily dose of fresh sewage, with its rich supply of food for them.

If the fresh sewage were entirely cut off would not the bacteria turn their attention to the sludge? If the upper layer were removed entirely and piled up by itself, would it not purify itself much more rapidly than anywhere in a filter where it is continually wet with new sewage? If this clogged material is removed, the filters will be able to continue doing the large amount of good work which they have

done in the past; they may do even more in some cases. The removed material may so purify itself in time as to again allow its advantageous use for filtration, but, if not, fresh sand must eventually be supplied. In actual practice with ample areas of filtering material a simple way of applying these ideas would be to abandon for a time an old area, after it had become clogged, without removal of the surface. How long a time would be required for such an area to regain its power of sewage purification, and what treatments would hasten the result, are subjects for further research.

Nature of the Sludge.

It may be queried whether piling up sand containing large amounts of organic matter stored from the sewage will not create a nuisance. To this we can answer no. The stored matters are the most stable portions of the sewage; they have resisted strong oxidizing action, and are incapable of rapid or objectionable decomposition. The matters which would have caused trouble had they been stored are just the ones which have been oxidized. The material should be so placed that a change of air in its pores will be possible, and no offence need be anticipated.

Amount of Sand necessary to be Renewed.

Filter No. 6 in four years' use has filtered 310,000 gallons of sewage, the equivalent of 62,000,000 gallons per acre. The upper 2½ inches of material now contain about 70 parts per 100,000 by weight of albuminoid ammonia, and the next 3 inches about 20 parts. To fully restore the filter to good working order we should remove the upper 2½ inches or 1.68 cubic yards for the filter, or 5.4 yards per million gallons of sewage treated. In July, 1891, when Filter No. 1 commenced to be seriously clogged, the layer with excessive organic matters was not more than 3 inches deep, although more than 400,000 gallons of sewage (80,000,000 gallons per acre) had passed. In this case the removal of two yards, or at the rate of 5 yards per million gallons of sewage treated, would have sufficed. In June, 1891, the surface of Filter No. 2 was clogged not more than two inches deep after filtering 230,000 gallons (46,000,000 gallons per acre), corresponding to 5.8 yards per million gallons. The sand below this upper layer contains some stored matter, which would be carried forward to the next account, and might eventually raise the amount of sand to be removed to eight or

even ten yards per million gallons. On the other hand, so far as this sand regains its power of purifying sewage this amount will be reduced. If the sewage contained more or less suspended matter, correspondingly more or less new sand would be required, and if the suspended matter was first removed from the sewage by settling, we may believe that the amount of sand to be removed would be very small. Experiments are now in progress to determine this point.

CHARACTER OF THE SEWAGE.

The sewage used at the Experiment Station is brought through a two and one-half inch pipe about 4,300 feet long from one of the main city sewers, as described in the special report upon the Purification of Sewage and Water (pages 3 and 34). A certain amount of the insoluble matters of the sewage, especially the sand, is deposited in the pipe, which requires to be cleaned at intervals. In order to get information in regard to the matters removed from the sewage by this deposit, on Jan. 26, 1892, when the pipe was cleaned by blowing out with water from a hydrant, samples of the water passing the pipe were taken. From the analyses of these samples, and an estimate of the quantity of water used to clean the pipe, was calculated the total amount of various substances washed from the pipe in pounds, and these reckoned on the entire quantity of sewage which had passed the pipe since the previous cleaning, showed how much the analysis of the sewage was changed by passing through the pipe. The results were as follows: —

	Total Amount Washed out in Pounds.	Reckoned in Parts per 100,000 on the Sewage Conveyed since Previous Cleaning.	Average Composition of Sewage at the Outlet of the Pipe during this Period.
Loss on ignition,	33.4	3.72	-
Fixed residue,	34.9	3.86	-
Albuminoid ammonia,	0.83	.09	.76
Oxygen consumed,	2.78	.31	4.52
Fat,	10.04	1.11	-

It thus appears that the matters retained in the pipe represented 10 per cent. of the albuminoid ammonia, and 6 per cent. of the oxygen consumed, and a much larger proportion of the fats.

The average composition of the sewage as received at the station during the past four years is as follows: —

[Parts in 100,000.]

	Free Ammonia.	Albuminoid Ammonia. Total.	Soluble.	Insoluble.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1888, ...	1.5528	.6878	.1611	.5267	5.19	0	0	-	1,000,000
1889, ...	1.8439	.5540	.2909	.2631	4.92	0	0	-	708,000
1890, ...	1.8200	.6862	.3805	.3057	5.45	0	0	3.25	1,085,000
1891, ...	2.2196	.7295	.3446	.3849	7.37	0	0	3.64	693,000
Average 4 years, .	1.8591	.6644	.2943	.3701	5.73	0	0	3.44	871,000

The strength of the sewage is slowly increasing, the average total nitrogen for 1891 being 25 per cent. greater than that for 1888.

The results of the daily sewage analyses since Nov. 1, 1889, are given in the following table:—

ANALYSES OF SEWAGE.

[Parts in 100,000.]

Date.	Free Ammonia.	Albuminoid Ammonia Total.	Soluble.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.	Date.	Free Ammonia.	Albuminoid Ammonia. Total.	Soluble.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.							**1889.**						
Nov. 1,	2.00	.45	.32	4.77	-	-	Dec. 4,	-	-	-	-	-	199,800
2,	2.65	.56	.34	4.87	-	-	5,	1.40	.41	.33	4.56	-	-
4,	2.75	.72	.48	8.52	-	-	7,	1.00	.37	.30	3.60	-	-
5,	1.75	.57	.32	4.70	-	535,000	9,	.80	.48	.32	2.80	-	-
6,	2.10	.52	.36	4.60	-	-	10,	1.00	.32	.26	3.90	-	304,200
7,	2.25	.63	.34	5.27	-	-	11,	1.20	.45	.27	4.47	-	-
9,	2.50	.94	.54	5.72	-	-	12,	1.10	.37	.28	4.02	-	-
14,	2.25	.62	.40	5.27	-	-	14,	.85	.45	.33	3.80	-	-
16,	2.00	.57	.42	9.00	-	510,800	16,	1.35	.73	.42	3.50	-	-
18,	2.15	.70	.49	9.68	-	-	17,	-	-	-	-	-	470,400
21,	1.65	.34	.24	4.19	-	119,400	19,	1.15	.60	.37	4.60	-	-
23,	1.75	.42	.26	4.57	-	-	20,	.85	.90	.34	5.95	-	-
25,	1.85	.67	.40	5.05	-	-	21,	1.80	.57	.29	3.65	-	-
28,	1.65	.38	.21	5.47	-	-	23,	1.23	.27	.20	3.65	-	-
30,	1.20	.38	.20	4.21	-	-	24,	1.30	.51	.34	4.47	-	-

The pipe leading from the Lawrence Street main sewer to the Experiment Station was cleaned out December 5.

ANALYSES OF SEWAGE — *Continued.*

Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.			
1889.						
Dec. 26,	1.05	.27	.22	3.52	-	-
27,	1.30	.47	.37	20.95	-	-
28,	1.07	.43	.29	5.95	-	237,900
30,	1.40	.49	.36	4.57	-	-
31,	1.55	.66	.32	4.40	-	-
1890.						
Jan. 1,	1.65	.41	.27	4.48	-	512,100
2,	1.60	.43	.35	4.08	-	-
3,	1.15	1.20	.28	10.05	-	-
4,	1.50	.88	.31	5.20	-	-
6,	1.65	.57	.37	3.70	-	-
7,	-	-	-	-	-	639,400
8,	1.40	.46	.26	4.70	-	-
9,	1.13	.53	.32	4.21	-	-
10,	1.60	.50	.30	4.58	-	-
11,	1.70	1.19	.33	4.62	-	-
13,	1.65	.47	.29	4.00	-	-
14,	-	-	-	-	-	860,000
15,	1.20	.63	.29	4.30	-	-
16,	.75	.60	.22	2.03	-	-
18,	1.27	.48	.37	4.72	-	-
20,	1.28	.31	.21	2.82	-	-
21,	-	-	-	-	-	544,500
22,	1.48	.43	.33	4.91	-	-
23,	1.50	.51	.29	4.88	-	-
24,	1.43	.66	.42	6.32	-	-
25,	1.27	.50	.27	7.97	-	-
27,	1.63	.46	.40	3.23	-	-
28,	1.85	1.63	.36	5.12	-	912,450
29,	1.43	.37	.31	4.23	-	-
30,	1.60	.36	.32	5.01	-	-
Feb. 1,	1.85	1.37	.34	5.57	-	-
3,	2.00	.71	.47	3.90	-	-
4,	-	-	-	-	-	508,200
5,	1.50	.52	.28	5.45	-	-

Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.			
1890.						
Feb. 6,	1.42	1.33	.29	4.10	-	-
8,	1.45	1.40	.33	4.37	-	379,400
10,	1.50	.59	.42	2.82	-	-
11,	-	-	-	-	-	379,500
12,	1.55	.37	.30	5.84	-	-
13,	1.55	.45	.34	4.92	-	-
14,	-	-	-	-	-	587,400
15,	1.85	1.84	.40	5.21	-	-
17,	2.00	.68	.50	3.79	-	-
18,	-	-	-	-	-	579,200
19,	1.50	1.06	.28	5.82	-	-
20,	1.45	.82	.55	5.13	-	-
22,	1.90	.90	.42	5.20	-	-
24,	1.35	.57	.41	3.12	-	-
26,	1.05	.37	.27	2.60	-	-
27,	1.15	.43	.29	2.82	-	-
Mar. 1,	1.15	.52	.31	4.92	-	-
3,	1.40	.28	.26	3.54	-	-
5,	1.50	.48	.40	4.18	-	-
6,	1.40	.70	.38	10.75	4.00	-
8,	1.12	1.23	.28	4.32	-	-
10,	1.70	.56	.48	4.92	-	-
11,	-	-	-	-	-	730,600
12,	1.70	1.16	.32	4.03	-	-
15,	.82	.58	.38	2.37	-	-
17,	1.08	.29	.23	3.19	-	-
19,	1.35	1.40	.38	4.55	-	-
20,	1.55	.49	.37	4.18	-	-
22,	1.30	.50	.23	3.67	-	-
24,	1.80	.42	.25	4.57	-	-
26,	1.25	.35	.30	5.27	3.00	410,500
27,	1.05	.68	.30	4.37	-	-
28,	1.01	.51	.27	4.67	-	-
31,	1.20	.39	.33	3.57	-	-
April 2,	1.25	.67	.25	5.02	3.80	-

Sewage pipe from Lawrence Street sewer cleaned out March 12.

ANALYSES OF SEWAGE — *Continued.*

Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.			
1890.						
April 3,	1.35	.70	.32	6.43	3.40	-
4,	1.55	.44	.35	4.12	2.50	-
7,	1.73	.50	.40	3.20	1.96	-
9,	1.38	.63	.38	4.77	-	-
10,	1.09	.68	.32	3.80	4.80	-
11,	1.30	1.14	.29	4.04	5.10	-
14,	1.60	.56	.40	3.83	2.60	-
16,	1.40	.47	.35	4.20	2.40	-
17,	1.75	1.06	.52	6.77	2.90	-
18,	1.60	.91	.55	4.03	-	-
21,	1.50	.64	.47	3.95	2.20	-
23,	1.42	.61	.40	4.85	-	-
24,	2.25	.52	.34	4.10	2.20	-
25,	1.90	.46	.29	3.72	2.00	-
28,	1.55	.44	.29	3.90	2.60	-
30,	1.53	.57	.43	4.40	2.10	-
May 1,	1.95	.44	.40	4.72	2.70	-
2,	1.60	.75	.63	3.99	1.70	-
5,	1.53	.45	.32	4.64	2.20	-
7,	1.25	.49	.26	4.60	1.90	-
8,	1.53	.37	.31	4.24	2.70	-
9,	1.65	.45	.35	4.50	2.00	-
12,	1.70	1.11	.43	4.42	4.70	-
14,	1.75	.55	.34	4.32	2.30	-
15,	1.75	.69	.37	5.80	2.80	-
16,	1.40	.70	.37	3.17	4.50	-
19,	2.05	.67	.47	10.92	2.70	-
21,	1.78	.50	.40	5.10	2.30	-
22,	1.85	.41	.29	5.42	2.00	-
23,	1.80	.62	.42	5.05	2.70	-
28,	1.65	.63	.26	4.30	2.60	-
29,	1.72	.82	.50	5.57	2.50	-
30,	2.20	.43	.27	4.62	1.50	-
June 2,	2.00	.67	.40	4.62	2.70	-
4,	1.85	.65	.29	5.04	3.80	-

Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.			
1890.						
June 5,	1.50	.45	.28	5.74	2.40	-
6,	1.80	.49	.30	5.00	1.68	-
10,	2.00	.52	.24	5.22	2.80	-
11,	2.00	.54	.28	5.22	3.10	-
12,	2.20	.55	.33	5.08	2.24	-
13,	2.00	.57	.35	4.85	1.96	-
16,	2.25	.62	.36	4.80	3.12	-
18,	2.25	.77	.38	6.00	3.60	-
19,	2.40	.75	.33	5.84	3.10	-
20,	2.25	.57	.33	5.62	2.30	-
24,	2.25	.78	.40	6.02	-	768,000
25,	1.50	.50	.33	7.40	3.60	-
26,	1.90	.50	.40	7.62	2.80	186,000
27,	1.90	.59	.42	4.82	2.20	-
30,	2.40	.66	.55	4.58	2.80	-
July 2,	2.00	.97	.57	5.32	3.20	-
3,	2.50	.65	.51	4.87	2.90	7,560,000
4,	1.90	.40	.28	8.62	1.90	-
7,	2.10	.81	.57	7.07	3.30	807,000
9,	2.00	.67	.42	7.25	2.40	-
10,	2.35	.65	.42	7.49	2.30	-
11,	2.50	.62	.52	4.87	2.00	-
12,	1.85	.68	.68	5.62	2.80	-
14,	2.75	.88	.88	5.97	3.00	159,060
16,	2.65	.91	.52	7.07	3.20	-
17,	2.75	1.05	.55	6.10	2.80	1,401,000
18,	2.35	.98	.48	6.17	3.10	-
21,	2.85	.76	.62	5.40	3.40	-
23,	2.50	.80	.57	6.17	2.10	-
24,	2.65	.70	.49	8.00	2.40	621,500
25,	1.25	.69	.38	3.02	2.70	-
26,	1.20	.97	.41	3.22	3.70	-
28,	1.90	.73	.40	4.82	3.90	-
30,	2.50	.63	.36	6.02	3.20	-
31,	2.50	.88	.46	7.40	2.30	1,278,000

Sewage pipe from Lawrence Street sewer cleaned out June 20.

ANALYSES OF SEWAGE — *Continued.*

Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.			
1890.						
Aug. 1,	2.10	.65	.28	5.27	3.40	-
4,	2.85	.68	.48	6.82	3.40	-
6,	2.75	.80	.41	5.92	4.00	-
7,	3.00	.83	.37	8.36	2.80	2,165,000
8,	2.75	.64	.45	6.98	2.40	-
13,	2.90	1.31	.43	19.67	4.30	-
14,	3.25	1.04	.39	15.00	8.60	1,977,000
15,	3.10	1.02	.36	8.67	3.80	-
20,	2.00	.54	.34	11.80	3.60	-
21,	2.47	.65	.37	8.94	2.80	1,651,800
22,	2.00	.78	.38	17.13	3.50	-
27,	.80	.37	.30	6.49	2.60	-
28,	2.10	.56	.36	7.94	2.80	-
29,	1.85	1.03	.53	5.92	4.90	-
Sept. 3,	1.90	.57	.44	5.62	3.00	-
4,	2.25	.67	.50	4.79	3.00	289,100
5,	2.20	.62	.45	4.67	2.30	-
9,	2.10	.64	.40	8.47	3.10	163,800
10,	.60	.41	.13	1.80	3.00	-
11,	1.85	.54	.36	6.40	2.10	-
12,	1.90	.56	.35	5.82	2.00	-
15,	2.00	.51	.38	5.17	3.00	-
17,	1.35	.51	.37	5.24	3.50	-
18,	1.65	.49	.33	6.22	2.40	-
19,	2.00	.36	.19	6.17	1.70	-
22,	2.10	.56	.28	4.97	2.30	-
24,	1.85	.47	.38	5.15	1.80	-
25,	2.40	.66	.39	5.02	2.80	-
26,	2.50	.50	.34	6.37	2.20	-
Oct. 1,	2.10	.56	.46	5.20	-	-
2,	2.15	1.08	.49	6.47	-	-
3,	2.35	1.02	.38	6.22	3.40	-
6,	2.85	.46	.33	6.07	3.60	-
8,	2.10	.44	.36	4.52	2.30	-
9,	1.75	.76	.53	5.72	7.00	-
1890.						
Oct. 10,	2.50	1.12	.28	5.50	6.00	-
14,	2.20	.87	.65	6.07	3.90	3,834,000
15,	1.85	.65	.47	5.97	3.30	-
16,	2.35	.56	.44	6.77	3.20	-
17,	1.00	.31	.19	2.02	2.30	3,222,000
22,	1.60	.48	.32	5.29	2.10	-
23,	1.40	.60	.43	6.02	3.30	-
24,	2.00	.43	.34	5.90	2.40	2,046,000
28,	1.75	.49	.30	5.15	16.30	846,000
29,	1.75	.83	.35	5.70	2.20	-
30,	1.70	.42	.26	5.17	2.00	-
31,	2.60	.55	.39	5.82	3.40	-
Nov. 4,	2.15	.54	.27	5.10	3.80	1,440,000
5,	1.90	.54	.41	4.90	2.70	-
6,	2.75	.62	.42	5.20	2.80	-
7,	2.10	.70	.34	5.61	3.30	3,180,000
11,	2.75	.74	.41	5.57	3.30	237,600
12,	2.00	.69	.52	5.82	3.80	-
13,	2.25	.62	.46	7.02	3.50	-
14,	2.00	.84	.41	5.37	3.40	846,000
18,	1.65	4.00	.40	4.07	7.20	1,818,000
19,	2.15	.60	.50	5.62	3.70	-
20,	1.90	.75	.37	5.32	5.40	-
21,	2.25	.85	.65	6.00	4.20	1,098,000
25,	1.50	.97	.55	4.14	4.30	534,000
26,	1.15	.47	.41	3.97	2.30	-
27,	1.75	.73	.58	4.16	3.60	-
28,	2.25	.76	.70	5.04	5.30	108,000
Dec. 2,	1.75	.58	.43	5.82	4.30	1,116,000
3,	2.50	1.17	.54	4.92	7.20	-
4,	.90	.76	.28	2.40	3.50	-
5,	1.35	.67	.40	4.20	3.30	630,000
9,	1.90	.66	.36	10.20	4.20	1,206,000
10,	2.35	1.00	.48	4.77	4.30	-
11,	1.75	.68	.44	10.30	4.10	-

Sewage pipe from Lawrence Street sewer cleaned out August 28 and November 21.

ANALYSES OF SEWAGE — *Continued.*

Date.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.						
Dec. 12,	1.40	.54	.34	5.22	4.20	1,152,000
16,	2.00	.55	.36	5.82	5.00	116,000
17,	2.35	.62	.40	4.22	4.20	-
18,	1.90	.68	.46	11.05	3.60	-
19,	.90	1.02	.24	3.80	2.40	696,000
23,	1.10	.40	.25	4.74	1.60	1,188,000
24,	1.50	.73	.37	3.97	3.30	732,000
26,	1.25	.48	.27	2.92	1.80	1,260,000
30,	1.25	.57	.25	4.20	2.50	648,000
31,	1.35	.99	.36	3.87	4.40	-
1891.						
Jan. 1,	2.00	.54	.29	3.47	2.50	-
2,	1.25	.28	.20	3.45	1.50	480,000
6,	1.00	.40	.22	12.12	3.40	546,000
7,	1.40	.47	.35	4.47	3.40	-
8,	1.90	.53	.32	5.12	2.00	-
9,	.90	.39	.22	2.85	1.20	522,000
13,	.70	.20	.15	2.20	1.30	296,000
14,	.90	.41	.21	3.57	2.50	-
15,	1.40	.45	.19	4.25	2.10	-
16,	1.75	.72	.23	-	3.50	834,000
20,	1.65	1.27	.41	4.16	3.40	600,000
21,	1.85	.68	.40	4.57	2.60	-
22,	2.35	.70	.34	8.95	3.20	-
23,	.80	.33	.24	3.30	2.40	354,000
27,	1.50	.32	.26	3.82	1.80	264,000
28,	1.43	.43	.38	4.57	3.40	-
29,	1.65	.46	.31	5.22	2.60	-
30,	1.75	.48	.28	4.17	1.60	216,000
Feb. 3,	1.10	.36	.28	5.20	2.50	152,000
4,	1.25	.38	.25	4.00	2.20	-
5,	1.40	.58	.35	4.72	3.10	-
6,	1.50	.93	.30	4.60	3.80	828,000
10,	1.40	.52	.35	4.17	2.50	35,000
11,	.90	.46	.20	3.77	2.20	-
1891.						
Feb. 12,	1.40	.69	.34	5.02	3.80	-
13,	1.50	.50	.26	4.55	4.00	818,000
17,	.90	.42	.24	3.27	2.80	124,000
18,	.90	.39	.25	2.82	2.10	-
19,	1.35	.27	.18	2.42	1.70	-
20,	1.40	.31	.24	4.00	1.00	138,000
24,	1.35	.68	.35	4.15	4.00	666,000
25,	1.25	.46	.27	3.17	3.20	-
26,	.75	.29	.17	1.72	2.20	-
27,	.90	.28	.19	2.57	1.80	150,000
Mar. 3,	.90	.36	.21	3.94	2.30	270,000
4,	1.35	.70	.30	4.22	2.10	-
5,	1.30	.51	.26	3.42	1.60	-
6,	1.60	.50	.27	4.17	2.40	398,000
10,	1.40	.61	.27	4.30	3.70	336,000
11,	.70	.37	.16	2.62	1.60	-
12,	1.10	.29	.18	3.62	1.60	-
13,	.90	.27	.14	3.40	1.60	1,314,000
18,	1.80	1.35	.21	3.47	4.70	-
19,	1.65	1.45	.25	3.87	6.90	-
20,	1.25	.30	.19	3.94	2.10	342,000
31,	1.75	.80	.21	7.65	3.80	720,000
April 1,	1.50	.51	.18	5.92	2.30	-
2,	1.65	.44	.17	5.22	1.50	-
3,	1.90	.58	.21	4.60	2.40	126,000
7,	1.20	.36	.22	7.27	1.60	480,000
8,	1.35	.30	.19	4.08	1.50	-
9,	1.25	.32	.15	5.87	1.30	-
10,	1.25	.31	.16	4.20	1.40	120,000
17,	2.00	.42	.16	4.22	2.10	168,000
21,	1.90	.61	.30	5.57	2.50	262,000
22,	1.50	.40	.18	4.37	1.40	-
23,	1.65	.32	.19	5.64	1.90	-
24,	1.15	1.15	.30	5.45	4.70	570,000
28,	1.80	.56	.40	5.52	2.70	900,000

Sewage pipe from Lawrence Street sewer cleaned out April 24.

ANALYSES OF SEWAGE — *Continued.*

Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.	Date.	Free Ammonia.	Albuminoid Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.						Total.	Soluble.			
1891.							**1891.**						
April 29,	1.60	.54	.30	4.44	2.90	-	July 1,	2.85	.77	.38	8.40	3.50	-
30,	1.85	.60	.29	6.30	2.90	-	2,	3.25	.72	.37	7.70	2.80	-
May 1,	1.85	.55	.29	4.22	2.30	1,350,000	3,	3.00	1.01	.48	10.18	4.30	428,000
5,	1.60	.56	.35	6.07	3.10	1,388,000	7,	2.76	1.13	.85	7.53	5.50	36,000
6,	1.40	.42	.25	4.70	1.70	-	8,	1.60	.46	.19	3.80	3.20	-
7,	1.85	.51	.36	5.90	2.30	-	9,	2.85	.49	.28	6.00	2.50	-
8,	1.90	.50	.84	7.78	2.40	2,160,000	10,	2.90	.62	.81	7.70	2.50	546,000
12,	1.85	.66	.43	5.22	3.70	1,440,000	14,	2.90	1.05	.42	6.80	4.80	688,000
13,	2.15	.68	.38	7.10	2.80	-	15,	3.00	.68	.31	8.05	3.50	-
14,	2.00	.82	.82	9.60	2.70	-	16,	1.90	.63	.42	7.10	3.00	-
15,	2.10	.64	.29	5.27	2.50	1,260,000	17,	2.90	.92	.52	42.20	3.80	-
19,	1.85	1.77	.31	8.70	6.00	1,386,000	21,	2.75	.82	.55	27.80	3.90	354,000
20,	2.15	.68	.36	5.37	2.80	-	22,	3.10	.79	.39	5.46	3.60	-
21,	2.15	.64	.34	5.50	3.00	-	23,	2.65	.64	.47	7.00	2.40	-
22,	2.20	.66	.31	6.90	2.90	1,440,000	24,	2.50	.80	.40	33.10	2.50	378,000
26,	2.25	.65	.36	14.35	3.50	-	28,	2.25	1.15	.37	5.25	4.90	1,430,000
27,	2.60	.62	.26	6.08	3.20	-	29,	1.75	.83	.27	9.30	5.20	-
28,	2.90	.67	.35	6.45	2.60	-	30,	2.40	.65	.29	6.00	4.00	-
29,	2.40	.89	.39	8.10	3.70	540,000	31,	1.60	.57	.30	4.70	3.20	406,000
June 2,	2.85	1.03	.39	18.25	4.80	1,098,000	Aug. 4,	2.65	.70	.41	7.12	3.00	700,000
3,	2.75	.85	.35	4.95	4.20	-	5,	2.90	.58	.32	8.88	2.50	-
4,	2.10	.52	.27	5.00	2.60	-	6,	2.75	.63	.38	5.95	3.00	-
5,	2.35	.59	.39	8.20	2.60	234,000	7,	3.75	.90	.42	6.70	5.00	240,000
9,	2.75	.75	.36	21.60	3.60	936,000	11,	2.50	.81	.32	6.36	3.70	-
10,	3.00	.70	.37	7.25	4.60	-	12,	2.60	.67	.40	7.25	3.40	-
11,	2.90	.85	.85	6.80	4.40	-	13,	3.15	.86	.54	8.50	4.10	-
12,	2.65	1.14	.39	26.10	3.80	368,000	14,	3.10	.93	.41	9.08	4.50	-
16,	2.90	1.06	.45	7.60	5.50	376,000	18,	3.00	1.10	.40	7.08	5.30	4,059,000
17,	2.75	1.03	.34	31.10	4.90	-	19,	3.00	.81	.42	7.30	4.90	-
18,	1.85	.88	.28	6.80	5.80	-	20,	3.65	.84	.35	7.40	4.10	-
19,	2.75	.81	.32	8.50	4.10	74,000	21,	3.00	.93	.55	11.25	6.50	994,000
23,	2.00	.78	.29	7.30	4.10	186,000	25,	2.65	.65	.39	5.70	3.50	1,746,000
24,	2.30	.97	.28	6.75	5.20	-	26,	2.35	.43	.27	12.90	2.40	-
25,	2.60	.78	.32	7.15	4.00	-	27,	2.75	.50	.26	6.73	2.40	-
26,	2.25	.61	.39	7.65	3.00	504,000	28,	2.50	.61	.28	6.38	3.60	505,000
30,	2.40	.71	.26	8.45	4.00	116,000	Sept. 1,	2.40	.60	.31	10.78	3.30	724,000

Sewage pipe from Lawrence Street sewer cleaned out July 15.

ANALYSES OF SEWAGE — *Concluded.*

Date.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.						
Sept. 2,	2.50	.63	.37	6.45	2.80	-
3,	2.90	.61	.32	5.75	2.90	-
4,	2.10	.40	.30	15.55	2.30	384,000
8,	1.40	.37	.23	6.63	2.70	880,000
9,	1.65	.42	.19	5.80	1.80	-
10,	2.25	.44	.30	8.95	2.30	-
11,	2.00	.51	.26	6.65	1.90	860,000
15,	2.50	.63	.23	8.60	3.30	392,000
16,	2.40	1.09	.40	6.60	5.70	-
17,	2.60	.82	.43	6.25	4.90	-
18,	2.60	.65	.43	8.45	3.00	-
22,	3.25	.83	.53	7.55	4.40	1,530,000
23,	3.40	.95	.48	10.00	3.60	-
24,	3.40	1.01	.48	8.15	3.60	-
25,	3.25	.98	.49	35.15	4.00	-
29,	3.25	.76	.43	7.75	3.40	954,000
30,	4.00	.90	.47	7.02	5.20	-
Oct. 1,	4.25	.79	.44	7.03	3.40	-
2,	3.15	1.25	.44	13.62	5.00	-
6,	3.25	1.07	.49	11.85	4.30	1,674,000
7,	3.40	.86	.48	7.25	3.90	-
8,	1.65	.79	.26	4.80	4.60	-
9,	3.00	.56	.37	9.35	3.10	-
13,	3.40	.87	.55	6.95	3.60	366,000
14,	2.00	.52	.32	4.73	2.50	-
15,	2.85	.84	.46	5.20	4.00	-
16,	3.40	.79	.49	6.70	4.40	-
20,	3.25	.78	.44	5.65	3.60	506,000
21,	2.65	.69	.41	5.38	4.20	-
22,	2.60	.74	.44	5.85	3.80	-
23,	2.85	.55	.37	9.40	2.90	-
27,	3.00	1.11	.42	8.40	5.20	684,000
28,	2.90	.78	.45	6.50	4.50	-
29,	2.90	.99	.53	5.60	4.70	-
30,	3.15	1.08	.59	7.90	6.10	-

Date.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.						
Nov. 3,	3.40	1.18	.40	15.10	7.20	874,800
4,	4.00	2.27	.33	6.75	8.40	-
5,	2.40	.65	.26	5.00	3.80	568,000
6,	2.80	.75	.36	9.70	3.70	-
10,	3.50	1.24	.56	8.80	6.50	355,000
11,	3.75	1.12	.59	13.40	4.40	-
12,	2.40	.71	.53	6.20	3.30	500,000
13,	3.40	.60	.40	8.20	3.80	-
17,	3.00	.64	.47	4.90	3.00	556,000
18,	3.60	1.16	.54	6.25	5.30	-
19,	3.00	1.04	.49	6.65	4.70	375,000
20,	2.75	.59	.39	7.25	2.90	-
24,	2.65	.77	.52	7.05	4.50	2,432,000
25,	2.60	.80	.41	6.00	3.40	527,000
27,	2.60	.65	.26	4.18	2.70	-
30,	3.50	5.75	.45	21.55	24.20	-
Dec. 1,	2.65	1.85	.89	6.60	16.60	379,000
2,	2.10	.83	.32	5.80	4.60	-
3,	2.50	.70	.37	7.02	4.00	365,000
4,	2.10	.69	.36	8.45	3.30	-
8,	2.50	.71	.46	5.90	3.50	607,500
9,	2.35	.48	.28	8.20	2.80	-
10,	1.75	.60	.40	5.58	3.00	291,200
11,	2.00	.65	.29	7.30	6.10	-
15,	2.85	.96	.44	16.80	6.20	526,000
16,	2.90	1.05	.41	7.03	5.30	-
17,	2.35	.88	.39	8.10	7.60	534,000
18,	2.00	.65	.39	8.15	5.00	-
22,	3.25	1.00	.54	14.35	6.00	478,000
23,	2.75	.79	.42	9.20	5.20	-
24,	1.20	.74	.29	4.90	5.60	670,000
29,	2.40	1.08	.49	12.95	6.00	1,111,000
30,	2.25	.74	.35	5.68	5.10	-
31,	1.50	.56	.31	4.10	3.70	240,000

Sewage pipe from Lawrence Street sewer cleaned out September 15 and December 9.

The following table contains a summary of fifty microscopical examinations of the sewage: —

Microscopical Examination of Sewage.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ. Chlorococcus,	2	100	5,000
Fungi.			
Beggiatoa,	16	30,000	480,000
Molds,	8	4,000	150,000
Saccharomyces,	100	3,000,000	16,800,000
ANIMALS.			
Infusoria.			
Monas,	98	300,000	1,940,000
Paramæcium,	98	200,000	920,000
Trachelophyllum,	4	1,000	2,500
Unclassified,	2	17,000	840,000
Vermes.			
Anguillula,	6	2,000	60,000
Rotifer,	2	300	15,000

FILTER TANK No. 1.

This is one of the large tanks having an area of one two-hundredth of an acre and containing for filtering material 5 feet 3½ inches of very coarse sand resting upon 3½ inches of gravel of various assorted sizes. The mechanical analysis of this sand is given on page 429. It has been in continuous use for sewage filtration since January, 1888.

The history of this filter for nearly two years of its use up to Nov. 1, 1889, was given in the special report upon the Purification of Sewage and Water (page 14). In November and December, 1889, some special experiments were made (described on page 672 of that report), showing that in its passage through the filter a portion of any particular dose of sewage passes a large part of the water previously held by the sand, particularly with large quantities of sewage, and this first portion may pass through the filter in too short a time to allow perfect purification. These experiments indicated that better results might be obtained by the more frequent application of smaller doses aggregating the same total amount, and soon after such a change was made.

In considering the results of these experiments, there was found to be a great decrease in free ammonia when the sewage passed the filter, in even so short a time as fifty minutes. It was queried whether actual ammonia could be removed in so short a time, and whether these results did not indicate that the so-called free ammonia of sewage was not really ammonia, but some extremely decomposable organic matter. To settle this point, enough ammonia as ammonium chloride was added to the sewage December 24 to double the free ammonia. Samples of the effluent were taken as before, and with precisely the same result; the added ammonia behaved in exactly the same way as the free ammonia of the sewage. This experiment, like all others which we have tried, gives no indication of a difference between the free ammonia of sewage and actual ammonia.

For about six months prior to Dec. 9, 1889, sewage was applied to this filter four times a week at an average daily rate of 57,100

gallons per acre; after this date until June 23, 1890, with the exception of December 23 and 24, sewage was applied at the rate of 51,400 gallons per acre daily, and from December 16 this was applied in three portions each day, for six days in the week, — one as early and one as late in the day as convenient, with a third midway between.

From Nov. 27, 1889, to April 8, 1890, the filter was protected from snow by the canvas cover used during the winter of 1888–89. During this period good, although not complete, nitrification was maintained, the nitrates averaging 1.17 parts for December to March and the free ammonia .0900 part per 100,000.

Early in April the sewage commenced to stand on the surface, excluding the air, and on April 8 the surface was raked, breaking up the slimy scum and allowing the sewage to soak away more rapidly. On April 18 the raking was repeated, and afterward the sewage disappeared promptly. As the weather became warmer nitrification became constantly more complete, until, in May, the ammonia was only .0044, with 2.53 nitrates.

On June 23 the tank was in good condition, and the amount of applied sewage was increased 50 per cent. to 77,100 gallons per acre daily; at the same time the raking of the surface of the sand to a depth of about one inch each week was begun. It was thought that perhaps with systematic breaking up of the scum on the surface a much larger amount of sewage could be applied without impairing the quality of the effluent.

The results obtained during July and August were so favorable that a further increase was made September 8 to 102,860 gallons per acre daily; the sewage was applied three times a day for six days in the week. With the weekly raking, the surface did not clog, and good results were obtained during September and October, although the nitrates were somewhat lower than before.

During the first winter sewage had been applied to this tank without any protection whatever, and no nitrification had been obtained. During the two following winters the filter had been protected from snow, and to a certain extent from cold, by a canvas cover; and under these conditions purification and nitrification had been maintained all winter. The filter was now in admirable condition, giving a very fair effluent, with a dose of 102,860 gallons per acre daily, and it was decided to leave it again unprotected from the weather to see what results could be so obtained. During the latter part of November

frost commenced to form in the sand, and the effluent deteriorated in quality.

December, 1890, was an extremely cold month, and thick cakes of ice were formed by the freezing of the sewage on the surface, which were removed on the 10th, 23d and 31st. By January 1 nitrification had nearly stopped, and the effluent was in a worse condition than ever before. The albuminoid ammonia in December was 15 per cent. of that of the sewage, and in January 20 per cent., while the oxygen consumed was 21 and 27 per cent., respectively. This is by far the worst result which has ever been obtained with this filter, but even then the effluent was better than could possibly have been obtained by chemical precipitation, for 80 per cent. of the nitrogenous organic matter was either oxidized or stored in the filter.

The sewage was applied during this time at the temperature which it had in the sewer, namely, 44° to 46°. About the 1st of February the filter commenced to improve very decidedly, and during February the free ammonia was .3700 with 1.09 nitrates; in March the figures became .0900 and 1.31, and in April .0065 and 1.57. During May the results were excellent, and also in the first part of June.

In the latter part of June the scum which had been each week, for more than a year, broken by raking had at last so filled the upper layers of sand with organic matter that simple raking was no longer effective in its removal. It re-formed so quickly after raking that sewage stood too long on the surface, preventing the circulation of air, and so causing imperfect purification, especially as the strong summer sewage requires more air for its oxidation than does the more dilute winter sewage.

It was judged from the appearance and analyses of the sand that it would be impossible to long obtain a good purification of the sewage the way the filter was then going, and an attempt was made to so change the treatment as to prolong the efficiency of the filter. On June 30 the surface was made into ridges and furrows, the ridges being about four feet apart and six inches high above the trenches. The ridges contained the old scum and the dirtiest sand, while the trenches were comparatively clean. It was our idea that the trenches would allow enough sewage to pass if the clogged surface was occasionally removed and placed on top of the ridges; and we expected that on top of the ridges, where it had full sunlight and was never wet except by rain, or by water drawn up by capillarity,

the conditions for its oxidation would prove more favorable than when it was repeatedly saturated by fresh sewage; and we hoped that by the time the trench had become too deep, by repeatedly removing its surface, the material so removed and meanwhile kept comparatively dry on the ridge would have so far purified itself that the positions of the ridges and trenches could be changed and the process repeated indefinitely.

At first the sewage undoubtedly went down too much in places, and the results were not so good as could have been desired; but after two or three weeks a marked improvement in the effluent took place, and in August we obtained free ammonia .0093 and nitrates 1.80. The material in the ridges was dry, and apparently much of the organic matter had been removed by oxidation; but while some oxidation undoubtedly took place in the ridges it was not so great as the appearance indicated. The following determination of ammonia in average samples of sand representing the ridges were made: —

[Parts in 100,000.]

1891.	Free Ammonia.	Albuminoid Ammonia.
July 1,	3	80
August 20,	5	55
October 13,	5.5	75

Of course the lower portions of these ridges were wet by sewage at each application and took up more or less organic matter from it. The greater part of this may have been oxidized, but some of the more stable matters must have remained to increase that of the ridges. The increased nitrogen, on October 13, was in part due to scraping the accumulated slime from the trenches and piling it on the ridges September 2.

On October 13 the position of the ridges and trenches was changed, giving a new surface to receive the sewage, and, commencing November 6, the sewage was applied only twelve times a week instead of eighteen, the size of the single doses being proportionately increased, so that the total amount applied remained unchanged. These changes, however, produced no marked or per-

manent improvement in the quality of the effluent, which was steadily deteriorating as the increase in the organic matters in the upper layers retarded the circulation of air; and it was not until this clogged surface material, five inches deep, was removed in 1892, after the period covered by the tables in this report, that the filter was completely restored to its original power of sewage purification.

In the following table are given the average analyses of sewage and effluent by six-month periods, from the beginning, January 10, 1888, with the quantity of sewage passing. It will be seen that during the colder half of the year, with the surface protected from snow, the results obtained were nearly as good as in the warmer months. In the winter of 1890–91, however, with the surface unprotected, nitrification was less perfect, and the effluent contained more organic matter and more bacteria than in the following summer, with the same quantity of sewage. In the last period of two months the effect of the clogging of the surface was beginning to show itself in the analysis of the effluent.

Average Analyses of Sewage and Effluent of Filter Tank No. 1, by Six-month Periods.

[Parts in 100,000.]

		Average Quantity. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January—April, 1888, . .	Sewage, .	32,400	.9389	.5953	2.61	0	.0027	-	1,328,550
Cold weather. Exposed, .	Effluent, .	37,400	.4227	.0390	2.45	.11	.0015	-	40,310
May—October, 1888, . .	Sewage, .	51,200	1.9117	.8790	6.33	0	.0005	-	1,491,191
Warm weather, . . .	Effluent, .	53,200	.0418	.0198	6.41	1.21	.0039	-	2,266
November, 1888—April, 1889,	Sewage, .	59,400	1.53[illegible]3	.3760	5.30	0	.0028	-	602,338
Cold weather. Protected, .	Effluent, .	58,600	.0912	.0268	4.85	1.13	.0018	-	2,282
May—October, 1889, . .	Sewage, .	56,200	2.1183	.6894	5.04	00	.0000	-	856,712
Warm weather, . . .	Effluent, .	55,400	.0423	.0277	4.97	1.81	.0014	-	1,568
November, 1889—April, 1890,	Sewage, .	47,800	1.5143	.6291	4.88	0	0	-	488,000
Cold weather. Protected, .	Effluent, .	46,600	.0929	.0341	4.28	1.30	.0017	-	4,236
May, 1890 — October, 1890, .	Sewage, .	79,400	2.0545	.6497	6.06	0	0	8.08	1,415,000
Warm weather, . . .	Effluent, .	76,800	.0121	.0309	6.83	1.59	.0018	.24	14,000
November, 1890—April, 1891,	Sewage, .	98,300	1.5308	.6173	4.73	0	0	2.98	621,000
Cold weather. Exposed, .	Effluent, .	97,900	.4933	.0601	5.34	.91	.0100	.45	25,000
May, 1891 — October, 1891, .	Sewage, .	103,200	2.6192	.7645	9.00	0	0	3.70	890,000
Warm weather, . . .	Effluent, .	103,200	.0789	.0386	9.23	1.50	.0273	.34	18,000
November and December, 1891, ...	Sewage, .	94,600	2.6922	1.0380	8.34	0	0	5.63	646,822
	Effluent, .	100,900	.3371	.0768	8.00	1.15	.0486	.52	46,355

The semi-weekly analyses are given in detail in the following table: —

FILTER TANK No. 1.

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889. Nov. 9,	41,428	49°	52°	20h.	-	**1889.** Nov. 7,	.0370	.0170	4.65	1.6000	.0008	-	3,604
16,	14,286	47°	51°	24h.	-	14,	.7000	.1600	4.82	.6000	.0150	-	1,518
23,	0	-	51°	-	-	21,	.0684	.0120	4.79	1.6000	.0008	-	8
30,	28,571	47°	49°	-	-	28,	.0288	.0098	2.90	1.4000	.0060	-	-
						29,	.0038	.0102	2.82	1.4000	.0040	-	-
Dec. 7,	71,428	44°	45°	-	1	Dec. 5,	.0010	.0190	.43	.3000	.0002	-	32
14,	57,143	37°	43°	-	-	12,	.1470	.0440	3.37	.7600	.0050	-	240
21,	51,429	45°	41°	-	½	19,	.1410	.0210	4.72	.9600	.0002	-	962
28,	54,286	45°	41°	-	1	26,	.1110	.0260	5.75	1.4000	.0014	-	1,782
1890. Jan. 4,	51,429	45°	42°	-	-	30,	.0720	.0340	6.35	1.3000	.0030	-	5,346
						1890. Jan. 2,	.1070	.0540	4.60	1.1000	.0024	-	7,854
11,	51,429	45°	41°	-	2¾	6,	.0970	.0540	4.22	.8000	.0025	-	14,688
						9,	.0164	.0186	4.57	1.2700	.0002	-	5,568
18,	51,429	45°	40°	-	3	13,	.0635	.0155	3.94	.8000	.0010	-	4,124
						16,	.0492	.0204	3.89	1.0000	.0004	-	4,320
25,	51,429	45°	39°	-	-	23,	.0384	.0196	4.07	1.1000	.0000	-	-
Feb. 1,	51,429	44°	38°	-	2	30,	.0824	.0252	4.52	1.0000	.0004	-	5,900
8,	51,429	45°	38°	-	1	Feb. 6,	.1380	.0340	4.22	1.1000	.0006	-	4,784
15,	51,429	44°	39°	-	-	10,	.2290	.0630	3.30	.7500	.0008	-	10,725
						13,	.2180	.0440	5.04	1.3000	.0004	-	2,528
22,	51,429	45°	38°	-	1½	17,	.1430	.0370	4.50	1.3000	.0006	-	2,808
						20,	.1080	.0350	5.67	1.4000	.0010	-	1,421
March 1,	51,429	45°	38°	-	-	24,	.0795	.0335	5.12	1.4000	.0006		6,912
					-	27,	.0592	.0296	3.90	1.1000	.0008	-	2,368
8,	51,429	45°	39°	-	½	March 3,	.0604	.0312	3.87	1.3000	.0008	.27	3,333
						6,	.1060	.0305	4.72	1.1000	.0002	.22	3,192
15,	51,429	45°	39°	-	-	10,	.0308	.0268	4.32	1.8000	.0016	.18	4,224
						13,	.0632	.0292	3.42	1.6000	.0004	.20	-

Sewage applied 4 times a week to December 16; afterwards 18 times.
Surface protected by canvas cover Nov. 27, 1889, to April 8, 1890.
Surface spaded up 4 inches deep November 27.
November 26, grass and weeds on surface pulled up.
November 28 to December 7, city water applied instead of sewage.
Effluent generally slightly turbid until February 10; afterwards clear.

FILTER TANK No. 1 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
Mar. 22,	51,429	45°	41°	-	-	Mar. 17,	.0332	.0300	3.40	1.8000	.0006	-	4,605
						20,	.0688	.0304	4.12	1.5000	.0006	.23	-
29,	51,429	45°	40°	2h. 14m.	-	24,	.0710	.0290	4.10	2.0000	.0008	.18	-
						27,	.0468	.0254	4.73	1.4000	.0004	.18	925
April 5,	51,429	45°	40°	26h.	-	31,	.0765	.0500	3.87	1.2500	.0014	.25	-
						April 3,	.0880	.0440	6.00	1.1000	.0008	.24	-
12,	51,429	45°	42°	-	-	7,	.0136	.0280	4.64	1.9000	.0004	.19	-
						10,	.0028	.0320	4.54	2.0000	.0004	.18	-
19,	51,429	45°	44°	-	-	14,	.0272	.0482	4.19	1.2500	.0020	.26	-
						17,	.0276	.0370	4.59	2.0000	.0010	.18	-
26,	51,429	47°	46°	-	-	21,	.0218	.0244	4.32	2.0000	.0004	.22	-
						24,	.0444	.0324	4.88	1.9000	.0010	.22	-
May 3,	51,429	49°	48°	-	-	28,	.0114	.0216	4.47	2.2500	.0004	.17	9,720
						May 1,	.0092	.0298	5.67	1.7000	.0006	.19	23,452
10,	51,429	53°	52°	-	-	5,	.0072	.0282	4.59	2.4000	.0001	.21	14,300
						8,	.0048	.0234	4.30	2.6000	.0001	.22	2,808
17,	51,429	57°	55°	-	-	12,	.0062	.0206	4.24	2.6000	.0001	.16	1,026
						15,	.0014	.0202	4.29	2.7500	.0001	.14	268
24,	51,429	58°	58°	-	-	19,	.0028	.0204	4.47	3.0000	.0000	.16	-
						22,	.0032	.0186	5.05	3.0000	.0002	.16	788
31,	51,429	58°	59°	-	-	29,	.0022	.0196	4.44	2.2500	.0002	.16	-
June 7,	51,429	60°	60°	-	-	June 5,	.0024	.0238	5.20	2.5000	.0006	.16	-
14,	51,429	61°	61°	-	-	12,	.0040	.0214	5.52	1.6500	.0002	.17	2,537
21,	51,429	61°	62°	-	-	19,	.0020	.0174	5.87	1.7500	.0000	.13	875
						24,	.0344	.0498	6.94	1.7500	.0024	.23	11,446
28,	77,143	70°	66°	-	-	26,	.0056	.0306	7.52	1.3500	.0004	.25	8,201
						28,	.0066	.0320	6.44	1.5500	.0028	.21	15,720
July 5,	77,143	72°	69°	-	-	July 3,	.0116	.0380	9.53	1.2000	.0002	.32	30,900
						5,	.0312	.0328	8.74	1.5000	.0020	.27	-
12,	77,143	72°	71°	-	-	10,	.0312	.0544	12.93	1.1000	.0050	.30	-
19,	77,143	72°	72°	-	-	17,	.0022	.0332	11.60	2.0000	.0010	.25	-
						19,	.0076	.0464	9.82	1.3500	.0010	.29	-
26,	77,143	70°	72°	-	-	24,	.0044	.0336	7.85	2.0000	.0006	.21	-

Sewage applied 18 times a week.
Surface protected by canvas cover until April 8.
Surface raked 1 inch deep April 8 and 18, June 12 and 29, and afterwards each week.
Effluent generally slightly turbid until April 24; afterwards clear and colorless or nearly so.

FILTER TANK NO. 1 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.						**1890.**							
Aug. 2,	77,143	73°	72°	-	-	July 31,	.0124	.0438	7.58	1.1000	.0006	.28	-
9,	77,143	75°	74°	-	-	Aug. 7,	.0106	.0414	8.50	1.2500	.0004	.34	66,198
16,	77,143	73°	74°	-	-	14,	.0306	.0531	8.67	1.4000	.0160	.41	107,400
23,	77,143	72°	73°	-	-	21,	.0064	.0394	6.37	1.8500	.0006	.27	35,280
30,	77,143	68°	70°	-	-	28,	.0040	.0220	7.14	1.7500	.0000	.20	-
Sept. 6,	77,143	66°	66°	-	-	Sept. 4,	.0298	.0588	7.33	1.5000	.0006	.27	5,162
13,	102,857	68°	69°	-	-	11,	.0032	.0242	5.42	1.1500	.0004	.24	7,056
20,	102,857	66°	68°	-	-	18,	.0144	.0250	4.19	1.7000	.0008	.26	-
27,	102,857	62°	66°	-	-	25,	.0046	.0206	6.78	.9000	.0000	.31	11,040
Oct. 4,	102,857	60°	62°	-	-	Oct. 2,	.0044	.0268	9.89	.7500	.0004	-	32,100
11,	102,857	59°	61°	-	-	9,	.0098	.0184	6.82	1.1500	.0000	.27	2,991
18,	102,857	54°	57°	-	-	16,	.0176	.0200	6.20	.9000	.0002	.22	12,390
25,	85,714	50°	54°	-	-	23,	.0228	.0242	4.93	1.0000	.0002	.28	7,080
Nov. 1,	102,857	48°	49°	-	-	30,	.0378	.0192	5.68	.9000	.0002	.28	13,680
8,	102,857	47°	47°	-	-	Nov. 6,	.0880	.0228	6.30	1.0700	.0004	.26	15,222
15,	102,857	45°	47°	29m.	-	13,	.0178	.0248	6.78	1.0300	.0006	.26	6,300
22,	102,857	43°	45°	-	1	20,	.3800	.0840	5.44	.5800	.0016	.62	55,320
29,	102,837	40°	42°	-	3½	26,	.1428	.0345	5.76	.8700	.0004	.29	21,240
Dec. 6,	102,857	44°	44°	-	5	Dec. 4,	.7500	.0890	3.27	.3400	.0012	.56	100,000
13,	102,857	45°	40°	-	4	11,	.9500	.1040	5.87	.5700	.0300	.68	54,000
20,	102,857	45°	37°	-	5	18,	1.2000	.1200	11.18	.4400	.0080	.64	62,640
27,	91,429	44°	37°	-	3½	24,	1.3000	.1300	4.79	.0600	.1000	1.16	60,660
						27,	1.0600	.0880	4.10	.1400	.0040	.66	54,000
1891.						**1891.**							
Jan. 3,	97,143	45°	36°	-	4½	Jan. 2,	1.3000	.1300	3.94	.0500	.0026	.80	32,040
10,	102,857	45°	35°	-	4	6,	1.4600	.1060	12.72	.1000	.0060	.68	111,600
						9,	1.6000	.1560	4.82	.0000	.0050	.91	115,200
17,	102,857	45°	36°	-	5½	13,	1.0000	.1000	2.62	.4200	.0060	.58	59,400
						16,	1.5000	.1000	5.24	.2000	.0040	.86	-
24,	102,857	45°	36°	-	3½	20,	1.2000	.0880	4.74	.2100	.0015	.67	29,520
						23,	1.0400	.0800	4.23	.5700	.0300	.63	29,700
31,	85,714	45°	36°	-	1½	27,	.9600	.1020	4.17	.8100	.0170	.63	15,660
						30,	.9600	.0580	5.61	.4100	.0090	.51	12,600

Sewage applied 18 times a week. Surface raked about 1 inch deep each week. Snow and ice removed from surface December 10, 13, 18, 23, 27, 31; January 6, 19, 26.

Surface raked (or picked) about 1 inch deep each week.

Experiment interrupted by high water in the river January 25, 26.

Effluent generally clear until November 13; slightly turbid November 20-26; afterwards quite turbid.

Filter Tank No. 1 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'ge Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Feb. 7,	102,857	45°	36°	-	4	Feb. 3,	.5200	.0680	4.09	1.1800	.0180	.50	5,520
						6,	.6000	.0620	4.32	.7000	.0060	.43	19,080
14,	102,857	45°	36°	-	2½	10,	.7000	.0580	7.75	1.0500	.0130	.47	10,800
						13,	.4000	.0540	4.45	.9460	.0200	.41	9,000
21,	102,857	45°	37°	-	1¾	17,	.2800	.0660	4.87	1.3500	.0170	.47	17,280
						20,	.2200	.0340	3.50	.7300	.0040	.33	3,600
28,	102,857	43°	37°	-	1¾	24,	.2700	.0440	6.64	1.3200	.0060	.38	7,200
						27,	.1300	.0300	2.53	1.3100	.0020	.13	2,640
Mar. 7,	102,857	44°	37°	-	2½	Mar. 3,	.2500	.0460	4.15	.7600	.0180	.33	4,560
						6,	.1460	.0280	3.90	1.0900	.0009	.26	9,720
14,	102,857	45°	38°	-	¼	10,	.0900	.0320	4.30	1.6400	.0050	.32	3,600
						13,	.0436	.0280	2.93	1.3400	.0018	.22	400
21,	85,714	45°	38°	-	1¾	20,	.0116	.0248	3.60	1.1900	.0004	.28	7,020
28,	34,286	40°	38°	-	¼								
April 4,	102,857	45°	41°	-	¼	31,	.0078	.0310	4.04	1.8800	.0002	.21	1,920
						Apr. 3,	.0062	.0268	4.07	1.1500	.0003	.21	2,400
11,	102,857	45°	41°	-	½	7,	.0066	.0220	3.82	1.3100	.0001	.18	3,240
						10,	.0036	.0236	4.80	1.2900	.0001	.21	540
18,	102,857	47°	46°	-	-	17,	.0082	.0228	4.35	1.6300	.0000	.20	8,460
25,	102,857	51°	51°	-	-	21,	.0060	.0270	9.58	2.2000	.0001	.24	2,220
						24,	.0074	.0196	4.92	1.6600	.0001	.21	1,140
May 2,	102,857	50°	52°	-	-	28,	.0074	.0210	8.40	1.7500	.0000	.23	2,280
						May 1,	.0070	.0270	4.67	1.0800	.0003	.28	18,000
9,	100,000	49°	51°	-	-	5,	.0042	.0216	11.37	1.4100	.0000	.23	8,100
						8,	.0084	.0230	5.20	1.3200	.0000	.23	8,640
16,	102,857	55°	54°	-	-	12,	.0060	.0220	5.40	1.5200	.0002	.26	16,200
						15,	.0058	.0254	6.50	1.7000	.0002	.25	12,780
23,	102,857	55°	56°	-	-	19,	.0204	.0280	9.80	1.9200	.0006	.31	12,600
						22,	.0080	.0272	7.98	1.6600	.0004	.28	1,500
30,	100,000	59°	60°	-	-	26,	.0024	.0226	8.11	2.2000	.0000	.26	7,200
						29,	.0160	.0346	6.75	1.9000	.0028	.33	13,500
June 6,	102,857	62°	62°	-	-	June 5,	.0148	.0300	7.65	1.5300	.0008	.28	4,060

Sewage applied 18 times a week. Surface raked (or picked) about 1 inch deep each week.
Snow and ice removed February 9, 10, 21, 27, March 2, 4, 5.
Experiments interrupted by high water in the river, March 14-16, 23-27.
Effluent slightly turbid during February; afterwards clear, or nearly so.

FILTER TANK NO. 1 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
June 13,	102,857	64°	63°	-	-	June 12,	.0212	.0424	9.20	.9800	.0060	.38	3,680
20,	102,857	67°	68°	-	-	19,	.1500	.0720	13.32	1.1000	.0070	.52	3,780
27,	102,857	66°	66°	-	-	25,	.0960	.0420	11.60	1.0200	.0030	.42	2,700
July 4,	102,857	66°	67°	-	-	July 2,	.0500	.0174	8.90	1.1000	.0030	.38	5,600
11,	102,857	67°	68°	36m.	-	7,	.1160	.0540	12.98	1.3100	.0120	.45	-
						9,	.0960	.0300	7.00	1.1500	.0022	.38	10,400
18,	102,857	71°	71°	20m.	-	14,	.2700	.1060	17.38	.3000	.0006	.78	35,360
						16,	.0440	.0520	7.20	.9300	.0080	.61	12,000
25,	102,857	70°	72°	-	-	21,	.0600	.0560	12.75	1.6200	.0014	.51	-
						23,	.0220	.0350	9.20	2.8400	.0006	.41	12,600
Aug. 1,	102,857	68°	71°	6h.	-	28,	.0029	.0226	8.54	2.6400	.0003	.24	1,270
						30,	.0028	.0268	6.68	2.2000	.0003	.28	2,000
8,	102,857	68°	70°	-	-	Aug. 4,	.0038	.0270	10.00	1.8500	.0005	.21	22,000
						6,	.0022	.0214	8.93	1.6700	.0001	.17	1,220
15,	102,857	71°	73°	-	-	11,	.0026	.0298	11.18	2.3300	.0005	.25	20,000
						13,	.0020	.0286	12.38	1.7600	.0008	.25	9,220
22,	102,857	70°	74°	47m.	-	18,	.0022	.0270	10.00	2.1100	.0002	.22	29,430
						20,	.0372	.0252	9.58	1.4700	.0012	.29	27,480
29,	102,857	71°	74°	-	-	25,	.0046	.0324	11.27	1.8500	.0006	.12	34,740
						27,	.0196	.0302	10.28	1.8700	.0036	.24	42,480
Sept. 5,	102,857	66°	70°	-	-	Sept. 1,	.0476	.0304	9.72	1.6300	.0006	.17	27,540
						3,	.0640	.0300	9.55	1.3500	.0016	.20	14,400
12,	102,857	66°	68°	-	-	8,	.0168	.0178	5.43	1.5300	.0010	.16	9,020
						10,	.0118	.0240	12.78	1.2200	.0014	.18	5,800
19,	102,857	67°	68°	-	-	15,	.0492	.0240	13.27	2.3000	.0010	.22	4,460
						17,	.0006	.0228	7.05	1.5000	.0006	.23	6,768
26,	102,857	68°	70°	-	-	22,	.0052	.0306	8.38	1.6300	.0006	.31	25,245
						24,	.0028	.0298	6.93	1.1500	.0005	.23	9,020
Oct. 3,	102,857	67°	70°	-	-	29,	.0400	.0332	11.77	1.4200	.0004	.27	20,340
						Oct. 1,	.0640	.0300	8.96	1.1800	.0009	.25	13,500
10,	97,143	63°	67°	5h. 30m.	-	6,	.0178	.0206	9.10	2.1000	.0009	.17	1,020
						8,	.0560	.0300	6.98	1.7200	.0600	.34	25,704

Sewage applied 18 times a week.
Surface made into ridges and trenches June 30; trenches raked about 1 inch deep each week.
Surface of trenches scraped on to ridges ½ inch September 2.
Effluent generally slightly or very slightly turbid.

FILTER TANK No. 1 — *Concluded.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Oct. 17,	85,714	55°	60°	18h.	-	Oct. 13,	.9500	.1380	6.88	.8500	.0008	1.16	24,600
						15,	.3200	.0800	7.25	1.1300	.0180	.56	23,625
24,	102,857	50°	56°	40m.	-	20,	.3300	.0820	11.40	.4000	.8000	.61	29,700
						22,	.3500	.0860	5.17	1.1300	.4500	.63	31,320
31,	97,143	45°	52°	-	-	27,	.3500	.0500	9.26	1.3600	.0240	.35	16,740
						29,	.1400	.0340	6.43	1.9100	.0120	.26	1,880
Nov. 7,	100,000	43°	47°	3h.	¼	Nov. 3,	.5000	.0740	9.92	.9000	.1400	.60	39,240
						5,	.3200	.0640	10.38	1.1500	.0090	.32	6,880
14,	85,714	43°	47°	-	-	10,	.3100	.0560	6.72	1.0600	.0090	.22	106,300
						12,	.2200	.0380	7.21	.8000	.0036	.42	1,900
21,	77,143	42°	47°	27h.30m	¾	17,	.2600	.0620	8.56	.5800	.0012	.44	6,000
						19,	.4800	.1200	8.03	.2700	.0000	.75	30,000
						24,	.7500	.1680	6.63	.1200	2.0000	-	122,400
28,	91,429	42°	45°	-	1	27,	.5500	.0660	6.42	1.4500	.0400	.55	85,600
Dec. 5,	102,857	38°	44°	1h. 17m.	1½	Dec. 1,	.3000	.0700	8.18	1.0000	.0440	.40	27,000
						4,	.4400	.0620	7.08	1.3200	.0220	.47	37,500
12,	102,857	43°	43°	53m.	½	8,	.4000	.1260	7.93	.9000	.1300	.77	16,300
						11,	.3700	.0980	7.33	1.1700	.0400	.65	150,000
19,	102,857	44°	42°	48m.	2¼	15,	.4200	.1140	10.08	1.0000	.1500	.85	32,000
						18,	.2500	.0760	7.58	1.3300	.0800	.66	57,000
26,	94,286	44°	41°	1h. 27m.	3	22,	.2400	.0900	5.80	2.0000	.0900	.49	46,000
						24,	.2600	.0960	6.97	1.4200	.0800	.72	56,000
						29,	.1900	.0780	8.02	1.3200	.0800	.60	84,000

Sewage applied 18 times a week until November 5; afterwards, 12 times.

Surface in ridges and trenches; trenches raked about 1 inch deep each week.

Surface of trenches scraped on to ridges as follows: October 31, ¼ inch; November 9, ¼ inch; November 18, 1 inch; November 30, ½ inch; December 26, ½ inch.

Positions of ridges and trenches changed October 13.

Effluent generally slightly turbid.

Chemical and Biological Examinations of Effluent of Filter Tank No. 1, representing the Different Parts of the Daily Flow.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.										
Nov. 30,	2.01	3,340	109	-	-	.87	1.0000	.0016	-	528
	3.00	2,980	159	.0028	.0138	1.37	.8000	.0012	-	594
	4.00	2,840	206	-	-	1.47	1.1000	.0020	-	462
	5.01	2,560	249	.0016	.0124	1.52	1.1500	.0008	-	297

Nov. 30. — City water equivalent to 100,000 gallons per acre applied from 10.37 to 12.10.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 7,	9.50	140	0	.0006	.0088	.80	.5500	.0002	-	35
	11.12	6,600	10	.0010	.0114	.45	.3000	.0000	-	193
	2.39	1,520	365	.0010	.0136	.38	.3400	.0001	-	-

Dec. 7. — City water equivalent to 100,000 gallons per acre applied from 10.27 to 11.30.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 9,	8.34	80	—4*	.0022	.0082	.70	.5700	.0001	-	24
	10.44	78	0	.0022	.0100	.75	.6500	.0001	-	-
	11.36	4,000	1	.0010	.0176	.52	.4400	.0001	-	-
	11.44	12,000	21	.0030	.0360	.56	.2200	.0006	-	3,828
	11.56	22,000	77	.0146	.0450	.94	.2600	.0008	-	14,580
	12.05	30,150	122	.0236	.0470	1.00	.2700	.0010	-	8,580
	12.17	13,920	173	.0220	.0514	1.06	.2800	.0010	-	7,740
	4.32	920	359	.0194	.0338	1.37	.3700	.0004	-	8,360

Dec. 9. — Sewage equivalent to 100,000 gallons per acre applied from 10.53 to 11.44. This was the first dose of sewage after applying water.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 23,	9.10	92	—1*	.0142	.0116	4.15	1.6800	.0002	-	182
	10.31	73	0	.0120	-	4.20	1.7500	.0002	-	-
	10.35	800	1	.0315	.0235	4.07	1.5500	.0009	-	-
	10.40	3,000	4	.0400	.0370	4.15	1.2500	.0022	-	-
	10.45	3,500	8	.0580	.0470	4.15	1.2000	.0020	-	-
	10.52	5,800	18	.0736	.0544	4.17	1.2000	.0028	-	-
	11.00	12,000	34	.0748	.0400	4.12	1.2000	.0024	-	-
	11.10	16,800	73	.1168	.0540	4.14	1.2500	.0024	-	-
	11.20	16,000	111	.1108	.0404	4.14	1.2000	.0024	-	-
	11.30	11,400	147	.1136	.0524	4.17	1.3300	.0022	-	-
	12.00	5,760	218	.0948	.0432	4.14	1.2500	.0016	-	-

Dec. 23. — Sewage equivalent to 100,000 gallons per acre applied from 10.30 to 11.00.

* Gallons passed after the sample and before flooding.

Chemical and Biological Examinations of Effluent of Filter Tank No. 1, representing the Different Parts of the Daily Flow — Continued.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.										
Dec. 24,	8.55	176	0	.0530	.0210	4.05	1.4000	.0004	-	627
	9.53	1,200	1	.0740	.0210	3.97	1.6000	.0004	-	-
	9.58	5,000	5	.0820	.0350	3.92	1.3500	.0014	-	-
	10.03	11,000	13	.1110	.0360	4.02	1.3000	.0028	-	-
	10.08	14,500	36	.1150	.0390	4.20	1.3000	.0035	-	-
	10.13	16,500	57	.1280	.0400	4.37	1.3000	.0030	-	-
	10.22	18,000	96	.1640	.0420	4.70	1.4000	.0050	-	-
	10.33	15,000	147	.1830	.0540	5.07	1.4000	.0050	-	-
	11.16	5,700	258	.1640	.0430	5.45	1.3000	.0050	-	-

Dec. 24. — Sewage equivalent to 100,000 gallons per acre, to which ammonium chloride equal to 2 parts of ammonia per 100,000 was added, applied from 9.11 to 10.11.

Day.	Hour.	Rate of Flow.	Amount Passed.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria.
1890.										
May 12,	8.52†	168	0	.0042	.0192	4.22	2.9000	.0002	.14	17
	3.35*	1,160	70	.0062	.0206	4.24	2.6000	.0001	.16	1,026
	7.00*	1,200	142	.0028	.0206	4.27	2.4000	.0000	.16	1,320
13,	5.00†	310	232	.0026	.0202	4.27	2.6000	.0000	.15	29

May 12. — Doses of sewage each equivalent to 20,000 gallons per acre applied from 9.02 to 9.14, 1.25 to 1.35 and 3.40 to 3.47.

Day.	Hour.	Rate of Flow.	Amount Passed.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria.
July 12,	8.00	270	0	.0030	.0214	9.73	1.6500	.0008	.19	1,006
	9.48	1,552	12	.0058	.0316	9.12	1.7500	.0010	.25	6,077
	11.15	1,040	42	.0032	.0264	9.42	1.7500	.0008	.21	11,760
	12.27	4,530	102	.0100	.0412	8.83	1.6500	.0008	.28	47,259
	3.36	1,060	202	.0032	.0288	9.18	1.7500	.0004	.21	4,602
	6.45	1,420	311	.0050	.0280	9.15	1.6000	.0004	.23	4,500

July 12. — Doses of sewage each equivalent to 30,000 gallons per acre applied from 8.44 to 9.00, 11.23 to 11.40 and 3.46 to 4.02.

Day.	Hour.	Rate of Flow.	Amount Passed.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria.
Nov. 15,	8.0	340	0	.0204	.0182	6.47	1.0800	.0000	.21	660
	1.33	1,100	3	.0528	.0198	6.04	1.2500	.0000	.21	1,220
	3.28	10,080	209	.4540	.1260	5.69	.4100	.1000	.72	19,680
	4.12	6,480	309	.2400	.0900	5.77	.7900	.0018	.44	35,100
	5.20	3,720	393	.1140	.0510	5.85	.8700	.0008	.33	22,140
	8.40	1,280	506	.0740	.0300	5.97	1.0900	.0002	.27	7,920

Nov. 15. — Doses of sewage each equivalent to 40,000 gallons per acre applied from 8.38 to 9.06, 1.25 to 1.52 and 2.54 to 3.22.

* P.M. † A.M.

Chemical and Biological Examinations of Effluent of Filter Tank No. 1, representing the Different Parts of the Daily Flow — Continued.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.										
Nov. 21,	8.40	350	0	.0352	.0208	4.92	.7000	.0001	.23	1,060
	1.33	1,320	108	.0540	.0228	5.20	.8300	.0001	.27	5,360
	2.39	5,100	150	.1040	.0260	5.18	.8300	.0005	.28	8,640
	3.20	4,260	200	.0820	.0310	5.42	.8900	.0003	.26	11,700
	4.59	5,580	300	.1800	.0400	5.47	.6700	.0004	.29	-
	8.40	2,040	502	.0750	.0220	5.57	.7600	.0001	.25	4,860

Nov. 21. — Doses of sewage each equivalent to 40,000 gallons per acre applied from 8.40 to 9 08, 1.29 to 1.55 and 3.58 to 4.16.

Dec. 4,	8.20	460	0	.5300	.0480	6.02	.5800	.0006	.36	8,640
	11.49	2,760	94	.6300	.0800	4.77	.6600	.0012	.50	36,720
	1.33	7,200	222	.9800	.0710	3.70	.3000	.0025	.55	49,800
	2.22	4,320	294	.8500	.0710	3.79	.2900	.0014	.56	44,020
	4.26	8,100	394	.9700	.0920	3.20	.2400	.0001	.52	81,600
	5.24	4,590	491	.7500	.0890	3.27	.3400	.0012	.56	100,000

Dec. 4. — Doses of sewage each equivalent to 40,000 gallons per acre applied from 8.39 to 9.01, 11.19 to 11.42 and 3.15 to 3.33.

1891.										
Feb. 13,	5.10	280	0	.4000	.0320	4.94	1.4800	.0060	.36	112
	7.43	3,020	26	.2500	.0640	4.52	.9900	.0090	.40	23,400
	8.25	1,940	50	.3000	.0300	4.64	1.2700	.0110	.37	2,500
	10.55	860	100	.4000	.0400	4.67	1.2500	.0060	.33	1,200
	1.25	3,600	200	.3800	.0460	4.52	1.2000	.0080	.36	6,600
	4.20	5,100	300	.4000	.0540	4.45	.9400	.0200	.41	9,000
	8.41	1,200	493	.3700	.0420	4.64	1.2300	.0120	.34	500

Feb. 13. — Doses of sewage each equivalent to 40,000 gallons per acre applied from 6.43 to 7.01, 11 43 to 12.01 and 3.35 to 3.48.

Mar. 13,	5.20	420	0	.0272	.0232	3.10	1.8300	.0012	.21	360
	9.12	2,220	20	.0284	.0268	3.00	1.5900	.0016	.22	2,100
	10.02	2,440	50	.0348	.0260	3.00	1.5000	.0016	.22	780
	11.20	2,440	100	.0356	.0244	3.00	1.3500	.0016	.22	200
	1.17	5,580	233	.0436	.0280	2.93	1.3400	.0018	.22	400
	2.29	3,060	302	.0478	.0248	2.88	1.4000	.0022	.22	1,920
	6.50	2,680	502	.0500	.0300	2.82	1.3600	.0022	.22	400

Mar. 13. — Doses of sewage each equivalent to 40,000 gallons per acre applied from 7.48 to 8.00, 11.17 to 11.32 and 3.33 to 3.46.

Chemical and Biological Examinations of Effluent of Filter Tank No. 1, representing the Different Parts of the Daily Flow — Continued.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.										
Apr. 17,	8.32	2,680	43	.0022	.0210	4.50	1.6400	.0000	.20	2,580
	10.23	1,520	100	.0046	.0190	4.50	1.7300	.0001	.19	1,380
	3.30	3,600	200	.0066	.0266	4.42	1.5300	.0001	.19	2,580
	4.54	7,500	302	.0082	.0228	4.35	1.6300	.0000	.20	8,460
	8.45	1,320	513	.0138	.0192	4.47	1.6900	.0000	.20	2,520
	5.37	350	604	.0068	.0186	4.47	1.8100	.0000	.17	3,980

Apr. 17.—Doses of sewage each equivalent to 40,000 gallons per acre applied from 6.38 to 7.01, 1.53 to 2.19 and 4.07 to 4.23.

May 22,	5.25	380	0	.0002	.0172	11.88	1.8500	.0001	.26	142
	8.25	1,800	20	.0002	.0202	9.27	1.6000	.0000	.28	6,300
	9.38	1,500	50	.0008	.0180	9.85	1.6400	.0000	.26	800
	12.13	1,080	100	.0006	.0176	10.30	1.7000	.0000	.26	162
	3.09	3,800	200	.0028	.0250	8.50	1.6700	.0000	.28	5,580
	4.40	8,460	300	.0080	.0272	7.98	1.6600	.0004	.28	1,500
	8.43	1,470	505	.0014	.0238	8.80	1.7300	.0000	.25	400

May 22.—Doses of sewage each equivalent to 40,000 gallons per acre applied from 6.55 to 7.12, 1.33 to 1.55 and 3.43 to 3.59.

July 16,	9.09	1,360	126	.0960	.0240	6.98	1.3300	.0020	.45	17
	2.38	1,260	325	.1040	.0380	7.16	1.2300	.0024	.48	3
	4.47	5,520	456	.0440	.0520	7.20	.9300	.0080	.61	12,000
	5.34	280	626	.0660	.0280	8.90	1.3100	.0022	.46	137

July 16.—Doses of sewage each equivalent to 40,000 gallons per acre applied from 6 40 to 6.55, 11.31 to 11.48 and 3.42 to 4.04.

Sept. 17,	8.31	1,680	1	.0028	.0172	7.50	1.6700	.0001	.21	4,384
	9.52	2,360	52	.0026	.0162	7.47	1.5400	.0001	.17	2,540
	11.35	1,360	102	.0012	.0162	7.50	1.6300	.0000	.19	366
	3.46	5,160	166	.0006	.0228	7.05	1.5000	.0006	.23	6,768
	4.16	4,680	202	.0040	.0226	7.03	1.6300	.0007	.25	5,648
	6.45	1,530	305	.0016	.0160	7.38	1.4100	.0001	.19	2,510

Sept. 17.—Doses of sewage each equivalent to 40,000 gallons per acre applied from 7.47 to 8.02, 3.00 to 3.16 and at 6.52.

Chemical and Biological Examinations of Effluent of Filter Tank No. 1, representing the Different Parts of the Daily Flow — Concluded.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.										
Dec. 8,	5.14	280	0	.3700	.0600	7.62	1.5400	.0100	.20	9,700
	8.42	14,400	50	.4800	.1060	9.20	.7800	.1500	.69	187,000
	8.59	8,760	100	.4700	.1220	8.98	.8200	.1600	.72	86,000
	10.49	1,780	200	.3700	.0720	8.30	1.4500	.0400	.49	50,400
	4.14	15,200	300	.3700	.1340	7.85	1.3300	.1500	.72	169,000
	4.52	6,240	400	.4000	.1260	7.93	.9000	.1300	.77	6,700

Dec. 8. — Doses of sewage each equivalent to 60,000 gallons per acre applied from 7.57 to 8.30 and 3.38 to 4.04.

The following table contains a summary of thirty-eight microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 1.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Synedra,	3	0.7	25
Algæ.			
Chlorococcus,	3	0.7	25
Ulothrix,	3	0.7	25
Fungi. Saccharomyces,	8	30.0	500
ANIMALS.			
Rhizopoda. Amœba,	3	0.7	25
Infusoria.			
Monas,	53	900.0	8,600
Paramœcium,	16	50.0	200
Vermes.			
Anguillula,	3	1.3	50
Rotifer,	8	3.	50
Rotatorian ova,	8	2.	25

Table showing the Amount of Nitrogen stored in the Sand at Different Depths, calculated from Determinations of Free and Albuminoid Ammonia, and deducting the 1 Part of Nitrogen contained in the Original Sand.

[Parts in 100,000 by weight of dry sand.]

DISTANCE BELOW SURFACE.	Dec., 1888.	Feb., 1889.	June, 1889.	Nov., 1890.	Apr. 16, 1890.	June 18, 1890.	Nov 24, 1890.	Mar. 25, 1891.	June 29, 1891.	Nov. 9, 1891.
0-¼ inch, . .	32.48	77.65	115.19	405.72	56.0	58.0	225.0	139.0	227.0	-
1 inch, . .	18.00	39.80	26.20	42.00	45.0	42.0	104.0	104.0	112.0	-
2 inches, . .	12.20	22.20	16.10	28.40	35.0	32.0	65.0	63.0	70.0	-
4 " . .	6.80	10.60	9.30	14.20	27.0	18.0	15.5	37.0	38.0	-
8 " . .	3.75	6.00	4.45	5.30	9.0	7.2	7.5	20.0	20.0	-
12 " . .	3.30	3.85	2.90	3.05	6.0	5.3	5.5	12.3	12.2	19.4
18 " . .	3.20	2.55	2.00	1.75	3.3	2.6	3.8	8.7	6.7	11.9
24 " . .	3.15	2.40	1.65	1.60	2.7	1.8	2.5	6.3	4.5	7.3
36 " . .	3.15	2.40	1.20	1.60	1.6	.5	2.0	2.9	3.4	3.1
48 " . .	2.70	2.40	1.05	1.15	.7	.3	1.0	1.2	2.3	1.9
60 " . .	1.65	2.40	.95	.75	.4	.2	.7	1.1	1.6	1.7

Table showing the Total Nitrogen applied to Filter Tank No. 1; the Amount in the Effluent; and the Amount stored in the Sand, in Pounds.

	Dec., 1888.	Feb., 1889.	June, 1889.	Nov., 1889.	Apr. 16, 1890.	June 18, 1890.	Nov. 24, 1890.	Mar. 25, 1891.	June 29, 1891.	Nov 9, 1891.
Total nitrogen applied to date, ...	16.62	18.83	24.96	35.63	42.93	46.41	63.05	73.66	84.85	104.47
Amount in effluent to date, ...	6.68	7.90	12.66	19.19	23.59	26.72	34.38	41.42	47.78	57.93
Amount stored in sand to date, ...	4.27	5.49	4.05	5.81	6.40	5.40	10.10	12.80	13.00	16.00
Amount lost to date, .	5.67	5.44	8.25	10.63	12.94	14.29	18.57	19.44	24.07	30.54
Per cent. stored, . .	26	29	16	16	15	12	16	17	15	15
Per cent. lost, . .	34	29	33	30	30	31	29	26	28	29

Distribution of the Stored Nitrogen in the Sand.

Upper quarter inch, .	.16	.37	.55	.96	.27	.28	1.07	.67	1.08	-
Upper inch, ...	.50	1.15	1.10	1.92	1.00	1.00	3.15	2.40	3.50	-
Upper three inches, .	1.04	2.07	1.78	2.93	2.40	2.30	6.40	5.00	5.60	-
Upper six inches, .	1.41	2.67	2.30	3.70	3.90	3.30	7.20	7.00	7.70	-
Upper foot, ...	1.77	3.25	2.75	4.31	4.60	4.20	8.30	8.90	9.40	11.10
Total five feet, . .	4.27	5.49	4.05	5.81	6.40	5.40	10.10	12.80	13.00	16.00

FILTER TANK No. 2.

This is one of the large filters, having an area of one two-hundredth of an acre, and containing five feet of fine sand, the mechanical analysis of which was given on page 429, supported by seven inches of coarse sand and gravel. It has been constantly in use for sewage filtration since January, 1888. It was described in the special report upon the Purification of Sewage and Water, pages 238 and 677. During the two years from November 1, 1889, it has continued to receive sewage at rates ranging from 42,000 to 60,000 gallons per acre daily.

During the first winter (November 27, 1889, to April 8, 1890) the filter was protected from the weather by a canvas cover, and good nitrification was maintained all winter. In the following winter the surface was allowed to remain unprotected. Snow was promptly removed from the surface, requiring about ten hours' work for one man for the winter. The full quantity of sewage was applied each week at a temperature of 44° to 46° and practically all passed the filter, for, of the 54,000 gallons per acre daily applied, from December to March, 50,000, or 92 per cent., appeared in the effluent. The cold weather and frost seriously checked but did not entirely prevent nitrification. The worst result was obtained in January, when the average free ammonia was .5725 parts per 100,000, and the nitrates .41 part. Even then purification was comparatively complete, for more than 95 per cent. of the albuminoid ammonia and 92 per cent. of the oxygen consumed were removed. In this case we have oxidation of the organic matters to ammonia and carbonic acid, and only partially to nitric acid. The conditions of oxidation are not quite so favorable, and the work is not so complete as when nitric acid is the end result; still, the fact remains that 90 to 95 per cent. of the organic matters have been removed, leaving the nitrogen mainly as ammonia instead of nitrates.

Commencing June 26, 1890, the surface was raked each week about one inch deep, preventing for the time at least, the accumu-

lation on the surface of continuous layers of organic matter, which would exclude the air and prevent purification. The amount of sewage applied was increased July 1 to 60,000 gallons per acre daily, and so effective was the raking that an entirely satisfactory effluent was constantly obtained with this increased quantity up to December 1. After that date the cold weather and frost interfered with the filter, as has been noted, the worst result being obtained in January, after which the effluent regularly improved until the first of May, although the nitrates were low. During May and June the surface was becoming so filled with organic matters that the weekly raking was no longer effective; the sewage remained on the surface from twenty to thirty hours; the quantity of air gaining admission to the pores of the filter was limited, while the stronger summer sewage required an increased amount. As a result of this, oxidation was imperfect, the ammonia increased and the nitrates were low, while the organic matters, as shown by albuminoid ammonia and oxygen consumed, were rapidly increasing. On July 25 the surface was made into trenches and ridges similar to those which had previously been made in Filter No. 1, but no improvement in the effluent was observed which could with certainty be attributed to these changes. The ammonia steadily increased.

On August 19 the dose was decreased from 60,000 to 42,800 gallons per acre daily, and for one week, commencing August 30, no sewage was applied. This short rest, together with the decreased quantity applied, proved adequate to bring the filter back to its old state of complete nitrification. The sample collected September 11 showed no improvement, but the one taken a week later had 2.00 parts of nitrates; from this time on the effluent steadily improved, the free ammonia decreasing to .0022 part October 23, and excellent results were afterwards obtained through the remainder of the year.

The following table shows the average work for the most important periods from the first application of sewage in January, 1888. From November, 1889, to March, 1890, good results were obtained with 41,000 gallons per acre daily. In the next period the quantity applied was for the greater part of the time at the rate of 60,000 gallons per acre daily, and, although this is a larger dose than can be permanently purified without change of sand at the surface, good results were obtained during this period. In the following period, cold weather checked nitrification, and it was not again

resumed with warm weather, owing to the excessive dose, with the choked surface. In October, 1890, there was a rapid increase in nitrates following a rest and reduction of the quantity applied, and in the last period is shown the result after nitrification had become again completely established.

Average Analyses of Sewage and Effluent of Filter Tank No 2, by Periods.

		Average Quantity. Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January—May, 1888, . . .	Sewage,	32,800	1.0128	.6745	2.80	0	0	-	1,273,551
	Effluent,	32,400	.3226	.0170	2.69	.03	.0011	-	3,039
June—August, 1888, . . .	Sewage,	22,000	1.6163	.4992	5.21	0	0	-	1,422,000
	Effluent,	20,000	.1917	.0137	6.81	1.51	.0324	-	177
September, 1888—February, 1889,	Sewage,	14,000	1.9181	.6855	5.83	0	0	-	442,924
	Effluent,	14,600	.0006	.0068	5.41	.79	.0000	-	76
March—October, 1889, . . .	Sewage,	29,800	1.9388	.5442	5.02	0	0	-	872,607
	Effluent,	29,600	.0042	.0089	5.31	1.25	.0012	-	26
November, 1889—March, 1890, .	Sewage,	40,600	1.5744	.6600	4.85	0	0	-	646,000
Cold weather; protected, . .	Effluent,	38,800	.0203	.0119	4.39	1.06	.0047	-	175
April, 1890—November, 1890, .	Sewage,	53,400	1.9587	.6701	5.80	0	0	3.16	1,600,000
Overdosing; good work at first,	Effluent,	53,600	.0016	.0105	5.61	1.85	0	.08	51
December, 1890—September, 1890,	Sewage,	45,400	1.9360	.6478	6.80	0	0	3.21	660,000
Cold; unprotected; overdosing,	Effluent,	47,800	.3628	.0283	7.30	.73	.0092	.24	134
October, 1891, ...	Sewage,	42,000	3.1555	.8467	9.12	0	0	4.17	1,000,000
Increasing nitrification with reduced quantity.	Effluent,	40,000	.1542	.0200	9.75	3.06	.0086	.12	26
November and December, 1891, .	Sewage,	34,600	2.6922	1.0380	8.34	0	0	5.63	646,822
Complete nitrification, . . .	Effluent,	35,400	.0057	.0098	7.46	1.71	.0003	.07	9

In the following table are the detailed results of the weekly examinations in continuation of those given in the report upon the Purification of Sewage and Water: —

FILTER TANK No. 2.

Week Ending—	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.													
Nov. 9,	14,286	46°	52°	-	-	Nov. 7,	.0190	.0086	6.32	1.3000	.0022	-	6
16,	0	-	52°	-	-	14,	.0276	.0096	6.47	.9000	.0150	-	240
23,	0	-	51°	-	-	21,	.0194	.0142	6.27	.6000	.0180	-	152
30,	14,286	47°	-	-	-	-	-	-	-	-	-	-	-
Dec. 7,	42,857	44°	46°	-	¾	Dec. 5,	.1000	.0600	4.40	.0000	.0000	-	8
14,	85,714	42°	44°	-	-	12,	.0120	.0060	.29	.7100	.0060	-	160
21,	42,857	45°	41°	1h.56m	0	19,	.0024	.0048	.18	.3000	.0010	-	25
28,	42,857	45°	41°	-	½	26,	.0162	.0108	5.05	1.1000	.0002	-	960
1890.													
Jan. 4,	42,857	45°	42°	-	-	Jan. 2,	.0415	.0165	5.10	1.3000	.0006	-	21
11,	42,857	45°	41°	-	2⅜	6,	.0330	.0140	7.60	1.1400	.0007	-	10
						9,	.0532	.0132	8.77	1.0400	.0006	-	46
18,	42,857	45°	40°	4h. 2m.	¾	16,	.0350	.0106	5.92	1.0000	.0006	-	-
25,	42,857	45°	39°	-	-	23,	.0196	.0118	4.02	1.0500	.0004	-	-
Feb. 1,	42,857	45°	38°	-	½	30,	.0106	.0092	3.44	.9000	.0004	-	-
8,	42,857	45°	38°	-	1	Feb. 5,	.0076	.0102	4.90	1.0000	.0004	-	12
15,	42,857	44°	38°	-	-	12,	.0042	.0098	4.10	.9000	.0002	-	165
22,	42,857	45°	37°	23h. 58m.	-	19,	.0050	.0106	3.90	1.0500	.0000	-	71
Mar. 1,	28,571	45°	38°	-	-	26,	.0118	.0114	4.67	1.1000	.0020	-	107
8,	42,857	45°	38°	2h. 56m.	½	Mar. 5,	.0168	.0128	4.44	1.2000	.0000	.08	271
15,	42,857	45°	38°	3h. 40m.	-	12,	.0296	.0148	3.62	1.6000	.0005	.12	231
22,	42,857	45°	40°	-	½	20,	.0354	.0122	4.27	1.6000	.0016	.11	44
29,	42,857	45°	39°	12h.	-	26,	.0282	.0132	4.00	1.8000	.0020	-	103
Apr. 5,	42,857	45°	40°	12h.	-	Apr. 2,	.0110	.0128	4.32	1.6000	.0008	.07	262
12,	42,857	46°	41°	11h 19m.	-	9,	.0028	.0104	4.62	1.4000	.0002	.06	38
19,	42,857	46°	43°	1h. 37m.	-	16,	.0016	.0118	4.54	1.7500	.0000	.09	192
26,	42,857	46°	45°	2h. 45m.	-	23,	.0016	.0140	3.93	1.7500	.0000	.10	202
May 3,	42,857	47°	47°	3h. 10m.	-	30,	.0010	.0116	4.20	2.4000	.0000	.08	80
10,	42,857	52°	51°	6h. 59m.	-	May 7,	.0010	.0122	3.90	2.5000	.0000	.08	75
17,	42,857	56°	54°	6h. 14m.	-	14,	.0012	.0116	3.90	2.7500	.0001	.09	571
24,	42,857	58°	57°	7h. 19m.	-	21,	.0018	.0128	3.92	2.5000	.0000	.07	158
31,	42,857	58°	58°	5h. 36m.	-	28,	.0026	.0128	5.57	2.2500	.0000	.07	3

Sewage applied November 1 and 8; city water applied November 29, December 2, 4, 6, 9, 10, 11, 12 and 13; afterwards sewage applied three times a week.

Surface protected by canvas cover November 27 to April 8.

Surface spaded up four inches deep November 27; raked one inch deep March 3 and April 8.

November 26, grass and weeds on surface pulled up.

Effluent turbid until December 5; afterwards clear and colorless.

FILTER TANK NO. 2 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
June 7,	42,857	60°	59°	26h. 8m.	-	June 4,	.0008	.0122	5.49	2.0000	.0000	.07	86
14,	42,857	62°	59°	-	-	11,	.0022	.0096	4.58	1.7500	.0000	.09	0
21,	42,857	64°	61°	-	-	18,	.0012	.0090	4.43	1.5000	.0000	.09	4
28,	42,857	71°	64°	-	-	25,	.0018	.0090	4.42	1.3500	.0000	.07	8
July 5,	60,000	71°	66°	3h.	-	July 2,	.0046	.0100	5.23	1.0000	.0000	.07	9
						5,	.0034	.0110	5.72	1.7500	.0000	.06	-
12,	60,000	72°	68°	-	-	8,	.0020	.0142	6.22	2.5000	.0000	.07	-
						12,	.0024	.0126	7.69	2.4000	.0000	.08	-
19,	60,000	73°	70°	1h. 30m.	-	19,	.0012	.0102	6.81	2.0000	.0000	.11	-
26,	60,000	71°	70°	1h. 15m.	-	23,	.0016	.0124	6.77	2.2500	.0000	.08	4
Aug. 2,	60,000	73°	71°	-	-	30,	.0018	.0120	6.00	2.1000	.0000	.06	78
9,	60,000	76°	73°	2h. 15m.	-	Aug. 6,	.0016	.0102	4.40	1.8500	.0000	.10	27
16,	60,000	73°	74°	2h. 32m.	-	13,	.0014	.0126	6.80	2.5000	.0000	.08	50
23,	60,000	72°	73°	4h. 27m.	-	20,	.0016	.0116	10.61	2.2500	.0000	.08	49
30,	60,000	68°	71°	-	-	27,	.0016	.0116	9.60	1.8500	.0000	.09	17
Sept. 6,	60,000	66°	70°	-	-	Sept. 3,	.0010	.0106	13.19	2.0000	.0000	.06	-
13,	60,000	67°	69°	2h. 39m.	-	10,	.0020	.0096	5.23	2.1000	.0000	.06	-
20,	60,000	66°	68°	-	-	17,	.0016	.0110	3.79	1.8500	.0000	.08	10
27,	60,000	62°	67°	-	-	24,	.0014	.0082	4.58	1.6500	.0000	.07	4
Oct. 4,	60,000	60°	64°	-	-	Oct. 1,	.0002	.0086	5.26	1.9000	.0000	-	21
11,	60,000	59°	62°	5h.	-	8,	.0002	.0074	5.58	1.7500	.0000	.08	8
18,	60,000	54°	60°	4h. 46m.	-	15,	.0002	.0080	4.95	1.4000	.0000	.08	10
25,	60,000	50°	56°	5h. 46m.	-	22,	.0006	.0102	7.64	1.5000	.0000	.08	29
Nov. 1,	60,000	47°	52°	-	-	29,	.0008	.0054	3.42	.8200	.0000	.07	15
8,	60,000	46°	50°	-	-	Nov. 5,	.0004	.0090	6.12	1.2800	.0000	.06	29
15,	60,000	45°	48°	-	-	12,	.0006	.0080	5.40	1.5100	.0000	.08	105
22,	60,000	42°	47°	22h. 43m.	1½	19,	.0008	.0086	4.82	1.5100	.0000	.08	5
29,	60,000	40°	45°	-	3¾	26,	.0008	.0098	4.78	1.3200	.0000	.10	3
Dec. 6,	45,714	42°	42°	-	3¾	Dec. 3,	.0030	.0106	5.45	1.4500	.0001	.08	8
13,	45,143	44°	40°	23h. 33m.	1½	10,	.0010	.0076	10.74	1.5000	.0000	.09	40
20,	60,000	45°	39°	36h.	2¼	17,	.0098	.0130	5.62	1.3500	.0009	.14	700
27,	60,000	45°	38°	-	1¼	24,	.0844	.0184	4.62	.5900	.0050	.16	390

Sewage applied 3 times a week. Surface raked about 1 inch deep each week, commencing June 26. Snow and ice removed from surface December 9, 11, 19 and 29.

Effluent clear and colorless.

FILTER TANK NO. 2 — *Continued.*

Week Ending —	Quantity Applied — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Jan. 3,	60,000	45°	37°	-	2½	Jan. 2,	.4000	.0320	4.72	.3000	.0026	.22	2,100
10,	60,000	44°	36°	-	3¼	7,	.5200	.0220	4.07	.5400	.0180	.20	1,260
						9,	.5300	.0240	3.87	.6700	.0200	.22	980
17,	60,000	44°	36°	-	2¾	16,	.6600	.0180	3.37	.4300	.0016	.15	-
24,	60,000	44°	36°	-	3	21,	.5500	.0180	2.70	.1900	.0032	.17	288
						23,	.5600	.0220	3.25	.3100	.0032	.20	176
31,	40,000	44°	37°	-	1	28,	.6600	.0300	3.74	.5400	.0016	.16	760
						30,	.7000	.0280	3.62	.3000	.0032	.18	188
Feb. 7,	60,000	44°	37°	14h.	2	Feb. 4,	.6200	.0260	3.52	.2900	.0040	.17	28
						6,	.7400	.0300	3.84	1.4500	.0050	.14	56
14,	60,000	44°	36°	-	2	11,	.6600	.0240	4.67	1.1800	.0012	.14	40
						13,	.5700	.0160	4.17	1.1600	.0034	.15	44
21,	60,000	44°	37°	-	1½	18,	.4800	.0320	4.27	.6300	.0022	.14	250
						20,	.4000	.0220	4.27	.6200	.0018	.14	108
28,	60,000	44°	37°	-	¾	27,	.3200	.0160	3.82	.8800	.0014	.12	19
Mar. 7,	60,000	44°	37°	-	1¼	Mar. 6,	.3000	.0240	3.67	1.2100	.0030	.12	108
14,	60,000	44°	37°	-	½	13,	.2200	.0220	3.68	.8500	.0018	.15	19
21,	40,000	44°	39°	-	2	20,	.1360	.0280	3.48	.6600	.0016	.15	20
28,	20,000	44°	38°	-	¾		-	-	-	-	-	-	-
Apr. 4,	60,000	46°	40°	27h.52m.	0	31,	.1800	.0360	3.20	.8500	.0040	.11	1
						Apr. 3,	.1360	.0180	3.25	.8500	.0040	.07	18
11,	60,000	45°	41°	36h.	0	10,	.2200	.0160	4.48	1.3100	.0080	.11	68
18,	60,000	46°	45°	30h.12m.	-	17,	.0592	.0112	4.27	.6900	.0026	.11	33
25,	60,000	51°	48°	30h.	-	25,	.0440	.0188	6.23	.2000	.0018	.20	80
May 2,	60,000	50°	50°	36h.	-	May 2,	.0660	.0180	4.70	.6000	.0000	.25	48
9,	60,000	50°	51°	20h.	-	8,	.1000	.0280	12.85	.5800	.0050	.29	110
16,	60,000	54°	52°	22h.	-	15,	.1700	.0260	5.55	.9200	.0050	.26	26
23,	51,428	55°	55°	27h.	-	22,	.3500	.0260	6.60	.3800	.0056	.30	26
30,	60,000	60°	57°	29h.20m.	-	29,	.2200	.0220	5.00	.2100	.0090	.27	12
June 6,	60,000	63°	60°	24h.	-	June 5,	.2600	.0400	7.12	.3200	.0150	.30	5

Sewage applied 3 times a week.

Surface raked (or picked) about 1 inch deep each week; spaded up 4 inches deep May 1, and 6 inches deep June 1.

Snow and ice removed January 5, 6, 12, 19; Feburary 9, 27; March 4 and 5.

Experiments interrupted by high water in the river January 25, 26; March 14-16, 23-27.

Effluent clear and colorless, or very nearly so.

FILTER TANK No. 2 — *Concluded.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
June 13,	60,000	63°	61°	26h.	-	June 12,	.2400	.0280	6.83	.1500	.0080	.34	2
20,	60,000	69°	64°	26h.	-	19,	.2100	.0380	10.08	.3100	.0080	.41	0
27,	40,000	67°	65°	30h.	-	26,	.4200	.0240	16.16	.6600	.0090	.38	0
July 4,	60,000	66°	65°	29h.17m.	-	July 3,	.2800	.0300	5.66	.8500	.0170	.40	1
11,	60,000	67°	65°	-	-	10,	.2700	.0180	9.32	.4700	.0090	.38	3
18,	60,000	71°	68°	36h.	-	17,	.3000	.0320	8.90	.1400	.0140	.47	2
25,	20,000	74°	70°	36h.	-	24,	.1000	.0460	10.05	.3100	.0090	.34	4
Aug. 1,	40,000	70°	69°	48h.	-	31,	.3300	.0480	14.65	.2500	.0036	.50	0
8,	60,000	68°	69°	18h.	-	Aug. 7,	.5300	.0420	14.40	.5500	.0300	.37	0
15,	60,000	73°	71°	-	-	14,	.7600	.0540	11.34	.4300	.0040	.51	1
22,	48,571	73°	71°	25h. 19m	-	21,	.9000	.0400	11.34	.3200	.0020	.39	0
29,	42,857	73°	72°	-	-	28,	.8300	.0420	10.60	.4200	.0080	.40	26
Sept. 5,	0	-	70°	-	-	Sept. 4,	.3300	.0420	10.28	.5500	.0024	.36	7
12,	42,857	65°	68°	12h.	-	11,	.9800	.0420	12.87	.2800	.0044	.33	16
19,	28,571	68°	67°	12h.	-	18,	.7500	.0360	10.48	2.0000	.0600	.24	6
26,	42,857	69°	69°	-	-	25,	.7200	.0460	10.16	2.6500	.0600	.18	23
Oct. 3,	42,857	69°	70°	-	-	Oct. 2,	.4800	.0340	9.78	2.8900	.0180	.20	13
10,	42,857	63°	67°	3h.30m.	-	9,	.2700	.0260	12.10	3.8400	.0200	.16	60
17,	42,857	55°	61°	-	-	16,	.0180	.0188	7.93	2.5000	.0050	.08	40
24,	42,857	51°	58°	-	-	23,	.0022	.0118	10.06	3.4300	.0000	.10	2
31,	42,857	45°	54°	12h.	-	30,	.0008	.0096	8.90	2.6400	.0002	.05	14
Nov. 7,	42,857	44°	51°	-	-	Nov. 6,	.0004	.0088	8.98	2.6400	.0000	.09	17
14,	42,857	42°	49°	12h.	-	13,	.0002	.0084	6.43	2.1100	.0002	.03	4
21,	42,857	41°	49°	-	1	20,	.0010	.0092	6.05	2.5500	.0000	.02	17
28,	42,857	41°	47°	12h.	-	27,	.0074	.0090	6.35	1.8800	.0000	.01	3
Dec. 5,	42,857	37°	46°	36h.	1	Dec. 4,	.0164	.0108	6.29	2.1900	.0006	.08	2
12,	42,857	42°	45°	-	½	11,	.0122	.0106	7.46	1.2800	.0009	.09	4
19,	14,286	45°	44°	-	½	18,	.0046	.0094	9.78	.6200	.0002	.13	13
26,	28,571	44°	43°	-	2	25,	.0042	.0126	8.36	.4000	.0012	.16	16

Sewage applied three times a week.

Surface raked one to three inches deep each week, until trenches were made July 25; afterwards surface of trenches raked one to two inches each week.

July 25 surface made into ridges and trenches.

Surface of trenches scraped on to ridges as follows: October 31, ¼ inch; November 13, ¼ inch.

Effluent clear and practically colorless, except from August 7 to September 11, when it was slightly turbid.

Chemical and Biological Examinations of Effluent of Filter Tank No 2, representing the Different Parts of the Daily Flow.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.										
Dec. 5,	9.28	-	0	.1000	.0800	4.40	.0000	.0000	-	-
5,	10.20	2,560	87	.0630	.0290	4.47	.1100	.0040	-	3
5,	4.34	2,240	592	.0272	.0124	4.40	.1000	.0026	-	3

Dec. 4. — City water equivalent to 100,000 gallons per acre applied from 11.27 to 12.07.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 9,	4.38	3,580	55	.0178	.0114	2.65	1.5000	.0200	-	-
10,	2.34	3,930	137	.0206	.0092	1.10	1.7700	.1100	-	84
11,	11.46	3,540	56	.0150	.0070	.50	1.2500	.0200	-	46
12,	1.40	3,940	57	.0120	.0060	.29	.7100	.0060	-	41
13,	11.19	4,360	-	.0126	.0062	.22	.5000	.0002	-	22
14,	1.40	2,060	25	.0078	.0048	.23	.3700	.0020	-	176
16,	3.36	2,140	15	.0052	.0054	.19	.3300	.0006	-	-
17,	9.49	780	19	.0056	.0062	.22	.3400	.0014	-	67
18,	11.50	1,080	39	.0060	.0038	.21	.3100	.0005	-	65
19,	8.40	240	112	.0024	.0048	.18	.3000	.0010	-	238
20,	11.44	2,100	22	.0054	.0062	.19	.3600	.0004	-	37
21,	12.00	250	446	.0032	.0104	.19	.4700	.0008	-	790
23,	7.00	3,720	64	.0046	.0086	.90	.2300	.0010	-	5,320
24,	2.37	300	412	.0046	.0158	2.57	1.3500	.0012	-	8,128
26,	9.55	280	452	.0162	.0108	5.05	1.1000	.0002	-	5,748
27,	2.00	3,200	117	.0278	.0098	5.82	1.0000	.0016	-	-

City water equivalent to 100,000 gallons per acre applied December 9, 10, 11, 12 and 13. Sewage equivalent to 100,000 gallons per acre applied December 14, 16, 18, 20, 23, 25 and 27.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.										
Jan. 29,	8.38	370	10	.0102	.0100	3.69	1.0000	.0004	-	63
29,	12.00	1,440	36	.0092	.0112	3.72	1.0000	.0004	-	65
30,	8.00	365	429	.0106	.0092	3.44	.9000	.0004	-	-

Jan. 29. — Sewage equivalent to 100,000 gallons per acre applied from 7.22 to 8.01.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Mar. 19,	6.55	140	0	.0216	.0130	4.18	1.4000	.0012	.10	11
19,	12.00	1,760	49	.0280	.0114	4.32	1.5000	.0010	.11	250
19,	2.34	2,750	156	.0406	.0116	4.32	1.4000	.0024	.10	216
19,	5.00	1,740	238	.0486	.0142	4.32	1.4000	.0024	.09	212

March 19. — Sewage equivalent to 100,000 gallons per acre applied from 7.29 to 8.20.

Chemical and Biological Examinations of Effluent of Filter Tank No. 2, representing the Different Parts of the Daily Flow — Concluded.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.										
July 16,	9.42	100	0	.0014	.0120	7.52	2.6500	.0000	.08	0
16,	11.21	4,920	49	.0010	.0106	7.27	2.5000	.0000	.07	3
16,	1.06	6,240	106	.0012	.0116	7.36	2.5000	.0000	.09	0
16,	1.58	6,000	201	.0010	.0106	7.32	2.5000	.0000	.09	0
16,	5.26	2,160	399	.0016	.0098	7.34	2.7000	.0000	.10	0
17,	11.10	240	600	.0012	.0100	7.17	2.6000	.0000	.08	1

July 16. — Sewage equivalent to 140,000 gallons per acre applied from 10.06 to 11.22.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.										
June 19,	9.25	420	0	.1260	.0360	9.83	.2900	.0090	.34	0
19,	2.10	940	50	.2100	.0380	10.08	.3100	.0080	.41	0
19,	5.25	920	95	.2300	.0320	10.28	.3300	.0080	.34	1
19,	8.40	860	159	.3200	.0300	10.54	.2200	.0070	.32	0
20,	2.58	880	400	.2700	.0340	11.98	.3400	.0360	.33	4
21,	8.50	52	603	.2700	.0400	13.90	.5100	.0220	.31	19

June 19. — Sewage equivalent to 140,000 gallons per acre applied from 10.35 to 11.51.

The following table contains a summary of twenty-four microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 2.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Asterionella,	4	1	25
Synedra,	4	4	100
Algæ.			
Chlorococcus,	12	5	75
Ulothrix,	16	4	25
Fungi.			
Molds,	4	5	125
Saccharomyces,	4	1	25
ANIMALS.			
Infusoria.			
Monas,	12	4	80
Paramœcium,	8	3	50
Vermes. Rotifer,	4	1	25
Miscellaneous. Starch,	4	1	25

Table showing the Amount of Nitrogen stored in the Sand at Different Depths, calculated from Determinations of Free and Albuminoid Ammonia, and Deducting the 0.83 Part of Nitrogen contained in the Original Sand.

[Parts in 100,000 by weight of dry sand.]

Distance Below Surface.	Dec., 1888.	Feb., 1889.	June, 1889.	Nov., 1889.	April, 1890.	July, 1890.	April, 1891.	June, 1891.	Nov., 1891.
0-¼ inch,	86.80	[100.00]	130.80	598.60	100.00	200.00	125.00	122.00	-
1 inch,	11.00	24.85	28.60	33.95	52.00	63.17	63.17	88.17	-
2 inches,	7.65	14.10	19.95	21.20	36.47	32.17	31.17	63.00	-
4 "	4.30	6.15	6.35	7.05	19.17	18.67	20.17	31.00	-
8 "	2.40	3.05	2.65	2.75	4.65	6.17	11.17	12.00	-
12 "	2.25	1.95	1.80	1.35	4.01	4.87	8.93	8.50	8.60
18 "	2.05	1.55	1.15	.60	1.82	3.40	5.57	4.55	5.00
24 "	1.95	1.40	.85	.45	.97	2.27	3.17	2.67	2.60
36 "	1.85	1.10	.80	.40	.27	.75	1.40	1.21	.90
48 "	1.55	.80	.80	.35	.17	.29	2.00	.90	.35
60 "	1.20	.50	.80	.30	.35	.27	3.27	.80	.17

Table showing the Total Nitrogen applied to Filter Tank No. 2; the Amount in the Effluent; and the Amount stored in the Sand, in Pounds.

	Dec., 1888.	Feb., 1889.	June, 1889.	Nov., 1889.	April, 1890.	July, 1890.	April, 1891.	June, 1891.	Nov., 1891.
Total nitrogen applied to date,	7.88	8.53	11.22	16.42	22.71	25.88	42.83	47.59	58.26
Amount in effluent to date,	2.54	2.78	4.78	6.81	10.02	12.67	22.37	23.76	28.17
Amount stored in sand to date,	2.94	2.61	3.35	4.60	4.81	5.65	8.07	9.08	9.61
Amount lost to date,	2.40	3.14	3.45	5.01	7.68	7.56	12.39	14.75	20.48
Per cent stored,	37	30	29	28	21	22	19	19	16
Per cent. lost,	31	37	31	31	34	29	29	31	35

Distribution of the Stored Nitrogen in the Sand.

Upper quarter inch,	.39	.45	.59	2.19	.45	.90	.56	.54	-
Upper inch,	.74	.76	1.01	2.64	1.53	1.80	1.64	1.96	-
Upper 3 inches,	1.00	1.16	1.87	3.54	2.90	3.10	3.20	3.96	-
Uppor 6 inches,	1.23	1.40	2.11	3.84	3.76	3.87	4.20	5.74	-
Upper foot,	1.49	1.76	2.35	4.18	4.22	4.44	5.54	7.08	7.96
Total 5 feet,	2.94	2.61	3.35	4.60	4.81	5.65	8.07	9.08	9.61

FILTER TANK No. 3 A.

The peat originally in Tank 3 was removed in November, 1889, and replaced by thirty inches of fine sand (No. 2) at the bottom and an equal amount of coarse sand (No. 1) on top. The object in view was to see if by this arrangement as large a quantity of sewage could be purified as with coarse materials, and at the same time secure a bacteria-free effluent such as is only obtained by filtering through fine materials.

From December 9, 1889, to January 4, 1890, city water was applied at the rate of 100,000 gallons per acre daily. Commencing January 6 sewage was applied at the rate of 25,700 gallons per acre daily, and a canvas cover was put over the filter to keep off the snow. At first the ammonia was removed, largely, no doubt, by storage in the sand, for there was no nitrification; but after two weeks there was a steady increase in ammonia until May 1, when the effluent contained .8300 part per 100,000.

Very slight nitrification was observed in March; the nitrates increased slowly at first and afterwards rapidly, reaching .30 part April 21, 1.00 April 28 and 3.70 May 12. After this the ammonia rapidly decreased to .0276 June 12, and remained comparatively low until December 1, always being under .0500, but quite variable from week to week.

On June 30 the quantity of sewage applied was doubled, and September 8 the rate was further increased to 60,000 gallons per acre daily and October 20 to 85,700 gallons.

In December the upper portion of the fine sand became clogged to such an extent that it obstructed the filtration, and sewage accumulated in the coarse sand above; air was excluded, and bad results were obtained. On December 22 the quantity of sewage applied was reduced to 51,400 gallons per acre daily, and, as no improvement in the effluent was noticed, further reductions were made to 14,000 gallons January 16, 8,500 gallons February 5 and 4,300 gallons March 7, which was continued through April. There was

slight nitrification in April, but sewage still stood in the coarse sand, and there was no indication of satisfactory results.

During May no sewage was applied, and on May 23 all the sewage had disappeared from the coarse sand, so that no part of the filter was saturated except the bottom layers of fine sand, which always hold themselves full by capillarity.

In June sewage was again applied at the rate of 8,700 gallons per acre daily; the nitrates increased to 3.47 on June 26, but the ammonia remained high. In July the nitrates became very high, but the amount of sewage which could be applied was not at all satisfactory; and the ammonia was very high. On August 6 an examination of the sand was made. It was found that there was a continuous layer of fine material just below the top of the fine sand. This stratification was doubtless caused by an unrecorded interruption in the filling of the tank. The material was thrown into water and the coarse particles fell at once to the bottom while the fine grains were held longer in suspension. After the filling stopped, these finer particles settled, forming a continuous layer over the entire surface of the sand. On top of this a very little more fine sand had been placed, and afterwards the coarse sand. As this nearly impervious layer was very thin, it was impossible to get a sample of it without including much sand from above and below. A sample about one-fourth inch thick, including this layer, had 15 parts albuminoid ammonia per 100,000. The original material had less than one part. As much of this sample was apparently clean sand unavoidably mixed with the material of the clogged layer, the layer itself must have contained much more than 15 parts.

We have then to attribute the failure of this filter to the clogging of a stratified layer of fine sand with organic matter. This layer was not of itself enough to choke the filter, as is shown by its first year's work; but it served to cause an unusual accumulation of organic matter in its pores, and when so clogged, this single layer, less than one-sixteenth of an inch thick, was able to ruin the filter.

On August 25, 1891, the coarse sand was removed and the fine sand spaded up, effectually breaking the fine layer, and then the coarse sand was replaced dry, and on August 27 sewage was applied at the rate of 51,400 gallons per acre daily. In two weeks the effluent was in good condition, and excellent results, similar to those obtained before the clogging, have since been obtained.

The average results for the most important periods are as follows: —

Average Analyses of Sewage and Effluent of Filter Tank No. 3 A, by Periods.

		Quantity Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January—May, 1890,	Sewage,	28,000	1.5157	.6633	4.69	0	0	2.99	583,000
Before complete nitrification,	Effluent,	29,000	.4350	.0418	3.60	.68	.0071	.12	4,670
June—November, 1890,	Sewage,	56,400	2.1072	.7011	6.09	0	0	3.30	1,372,000
Complete nitrification,	Effluent,	58,800	.0263	.0113	5.84	1.66	.0042	.08	1,018
December, 1890—August, 1891,	Sewage,	14,600	1.9144	.6503	6.70	0	0	3.19	698,000
Clogged by fine layer,	Effluent,	15,000	1.2464	.0559	5.71	1.31	.0250	.44	10,000
September—December, 1891,	Sewage,	51,200	2.7558	.9032	8.39	0	0	4.69	729,715
After removal of fine layer,	Effluent,	51,000	.0850	.0168	8.04	2.36	.0134	.17	3,318

The results of the weekly analyses are given in full in the following table: —

FILTER TANK NO. 3 A.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.				Free.	Albuminoid.		Nitrates.	Nitrites.		
1889.													
Nov. 30,	0	-	47°	-	-	Nov. 25,	.0028	.0056	.32	.0300	.0005	-	-
						28,	.0034	.0044	.42	.0360	.0002	-	-
Dec. 7,	0	-	44°	-	3½	Dec. 5,	.0064	.0050	.52	.0350	.0006	-	73
14,	85,714	43°	45°	-	-	9,	.0066	.0044	.40	.0500	.0001	-	2,652
						12,	.0064	.0036	.31	.0500	.0002	-	230
21,	85,714	42°	41°	-	-	17,	.0046	.0038	.22	.0220	.0000	-	491
						19,	.0040	.0018	.18	.0180	.0000	-	249
28,	85,714	41°	40°	-	-	26,	.0050	.0034	.19	.0300	.0000	-	314
1890.													
Jan. 4,	85,714	41°	41°	-	-	Jan. 2,	.0062	.0040	.18	.0190	.0002	-	41
11,	25,714	37°	41°	-	3½	9,	.0042	.0040	.18	.0200	.00 0	-	10
						11,	.0032	.0026	.18	.0200	.0000	-	-

City water applied 6 times a week to January 4; afterwards sewage applied 6 times a week.
Surface protected by canvas cover from January 7 to April 8.
Effluent clear and colorless.

FILTER TANK NO 3 A — *Continued.*

WEEK ENDING —	Quantity Applied. Gallons per Acre Daily.	TEMPERATURE. Sewage.	TEMPERATURE. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
Jan. 18,	25,714	35°	40°	28m.	3¾	Jan. 13,	.0034	.0118	.56	.0200	.0004	-	383
						16,	.0044	.0158	1.22	.0200	.0004	-	24,200
25,	25,714	36°	39°	-	-	20,	.0044	.0192	2.82	.0100	.0004	-	-
						23,	.0180	.0162	2.42	.0100	.0008	-	-
Feb. 1,	25,714	35°	38°	-	4	28,	.0266	.0126	2.72	.0200	.0004	-	-
						30,	.0412	.0162	3.07	.0300	.0020	-	29,568
8,	25,714	35°	39°	-	3½	Feb. 3,	.1090	.0334	3.72	.0100	.0070	-	118,900
						7,	.1930	.0260	3.72	.0200	.0010	-	-
15,	25,714	36°	38°	-	-	10,	.1710	.0270	3.62	.0100	.0016	-	19,694
						13,	.3160	.0420	3.62	.0100	.0014	-	36,960
22,	25,714	35°	37°	-	3	17,	.5260	.0300	3.65	.0200	.0004	-	-
						20,	.5000	.0400	3.80	.0100	.0004	-	2,635
Mar. 1,	25,714	35°	37°	-	-	24,	.4200	.0500	3.90	.0200	.0003	-	4,158
						27,	.5700	.0700	4.22	.0200	.0000	-	6,148
8,	25,714	35°	37°	17m.	3	Mar. 3,	.5700	.0600	4.55	.0200	.0000	.18	990
						6,	.6560	.0580	4.15	.0200	.0000	.11	-
15,	25,714	36°	37°	-	-	10,	.5300	.0500	3.75	.0200	.0004	.10	4,242
						13,	.6300	.0500	3.89	.0200	.0002	.13	13,530
22,	25,714	37°	38°	-	1¼	17,	.5700	.0400	4.24	.0200	.0004	-	10,560
						20,	.4500	.0400	3.40	.0400	.0002	.12	1,062
29,	25,714	38°	38°	20m.	-	24,	.5300	.0500	3.92	.0500	.0014	.15	-
						27,	.7200	.0600	3.52	.0500	.0002	.11	25,758
Apr. 5,	25,714	40°	39°	18m.	-	31,	.6200	.0300	3.59	.1000	.0018	.10	-
						Apr. 3,	.6200	.0900	4.32	.1100	.0008	.12	5,850
12,	25,714	42°	40°	-	-	7,	.6500	.0700	4.43	.1300	.0040	.11	612
						10,	.7000	.0600	4.67	.1000	.0006	.10	1,265
19,	25,714	45°	44°	-	-	14,	.6800	.0600	4.82	.1500	.0010	.14	6,048
						17,	.6700	.0700	4.72	.1500	.0006	.11	7,956
26,	25,714	47°	47°	-	-	21,	.7000	.0700	4.57	.3000	.0016	.11	9,828
						24,	.7600	.0800	4.64	.3500	.0014	.11	1,210
May 3,	25,714	49°	48°	-	-	28,	.8000	.0600	4.39	1.0000	.0040	.11	848
						May 1,	.8300	.0400	4.30	1.6000	.0050	.12	376

Sewage applied 6 times a week.
Surface protected by canvas cover January 7 to April 8.
Surface raked 1½ inches deep February 18.
Effluent generally clear and colorless.

FILTER TANK No. 3 A — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
May 10,	25,714	53°	52°	-	-	May 5,	.7200	.0600	4.57	2.0000	.0080	.12	682
						8,	.8000	.0800	4.34	2.7500	.0120	.14	6,318
17,	25,714	56°	55°	-	-	12,	.5800	.0400	4.00	3.7000	.0240	.10	-
						15,	.4500	.0300	3.82	3.7500	.0220	.10	956
24,	25,714	58°	58°	-	-	19,	.3400	.0280	3.90	3.7500	.0700	.17	1,368
						22,	.4300	.0200	3.98	3.5000	.0500	.15	-
31,	25,714	58°	59°	-	-	29,	.3400	.0440	4.67	2.9000	.0400	.20	532
June 7,	25,714	61°	60°	-	-	June 5,	.1480	.0290	4.57	2.5000	.0300	.09	-
14,	25,714	61°	61°	-	-	12,	.0276	.0114	4.46	2.0000	.0001	.07	0
21,	25,714	64°	63°	-	-	19,	.0126	.0100	4.62	2.0000	.0004	.05	59
28,	25,714	70°	65°	-	-	26,	.0790	.0106	5.07	2.0000	.0040	.06	33
July 5,	51,428	72°	68°	-	-	July 3,	.0476	.0104	7.12	2.3500	.0400	.05	503
						5,	.0134	.0130	6.72	2.2500	.0040	.06	-
12,	51,428	72°	70°	-	-	10,	.0288	.0118	6.66	1.6000	.0080	.08	616
						12,	.0256	.0120	6.29	1.6000	.0060	.08	2,580
19,	51,428	72°	72°	-	-	17,	.0152	.0104	8.20	1.8500	.0040	.09	0
						19,	.0206	.0118	9.72	1.7500	.0016	.10	1,275
26,	51,428	71°	72°	-	-	24,	.0030	.0140	8.84	1.5000	.0004	.06	181
Aug. 2,	51,428	72°	73°	-	-	31,	.0042	.0112	4.89	1.5000	.0026	.07	254
9,	51,428	74°	75°	-	-	Aug. 7,	.0040	.0086	5.63	2.2500	.0002	.07	363
16,	51,428	73°	73°	-	-	14,	.0016	.0082	7.04	2.3500	.0008	.06	1,206
23,	51,428	72°	75°	-	-	21,	.0082	.0110	10.13	2.0000	.0008	.06	4,998
30,	51,428	68°	72°	-	-	28,	.0020	.0096	5.88	1.5000	.0002	.07	0
Sept. 6,	51,428	66°	71°	-	-	Sept. 4,	.0028	.0088	7.17	1.5000	.0000	.06	-
13,	60,000	68°	70°	-	-	11,	.0018	.0106	5.71	2.0000	.0002	.09	-
20,	60,000	66°	69°	-	-	18,	.0100	.0094	5.02	1.2500	.0044	.08	-
27,	60,000	62°	68°	-	-	25,	.0322	.0076	5.94	1.7500	.0024	.10	2,220
Oct. 4,	60,000	60°	66°	-	-	Oct. 2,	.0186	.0082	5.22	1.6000	.0040	-	423
11,	60,000	59°	63°	-	-	9,	.0142	.0092	4.64	1.3500	.0040	.10	333
18,	60,000	54°	60°	24m.	-	16,	.0026	.0082	4.94	1.1000	.0000	.08	3,960
25,	71,428	50°	56°	40m.	-	20,	.0092	.0110	5.44	1.4000	.0004	.11	-
						23,	.0320	.0102	2.92	.8500	.0008	.09	317

Sewage applied 6 times a week.
Surface raked about 1 inch deep each week, commencing July 1.
Effluent clear and colorless.

FILTER TANK No. 3 A — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
Nov. 1,	85,714	47°	52°	-	-	Oct. 28,	.0424	.0112	5.22	1.1000	.0060	.13	17
						30,	.0194	.0096	5.22	.9000	.0010	.15	2,820
8,	85,714	46°	49°	-	-	Nov. 4,	.0164	.0104	5.62	1.2300	.0030	.11	494
						6,	.0308	.0104	6.34	1.4000	.0012	.09	302
15,	85,714	45°	48°	62m.	-	11,	.0216	.0118	4.02	1.5400	.0002	.10	72
						13,	.0360	.0128	6.82	.9600	.0008	.07	188
22,	85,714	42°	46°	-	1	20,	.0370	.0128	4.82	1.0700	.0030	.12	160
29,	85,714	39°	45°	-	5	27,	.0484	.0192	6.22	1.1100	.0006	.15	1,140
Dec. 6,	85,714	43°	40°	-	5½	Dec. 4,	.1665	.0195	5.35	1.1000	.0045	.20	9,720
13,	71,428	46°	40°	-	5½	11,	.2600	.0260	4.32	.1600	.0009	.24	62,100
20,	28,571	44°	38°	-	5	18,	.1200	.0580	5.80	.4700	.0060	.25	132,480
27,	51,428	45°	38°	18h.	5	24,	.8000	.0680	5.44	.1800	.0200	.54	95,400
						27,	.8000	.0720	5.54	.1000	.0045	.60	39,600
1891.													
Jan. 3,	35,571	45°	38°	-	10	Jan. 2,	1.2000	.1000	5.50	.0300	.0001	.68	31,600
10,	42,857	45°	36°	-	7½	6,	1.1000	.0780	5.42	.0000	.0005	.61	23,040
						9,	1.1600	.0780	5.60	.0100	.0008	.64	11,520
17,	37,143	46°	37°	24h.	-	13,	1.1000	.0700	5.77	.0100	.0004	.60	8,880
						16,	1.7000	.0660	6.00	.0000	.0010	.69	49,500
24,	14,286	45°	37°	24h.	1	20,	1.6600	.0640	7.95	.0600	.0008	.62	8,540
						23,	1.7000	.2000	10.56	.0100	.0015	.65	500
31,	14,286	48°	37°	-	1½	27,	1.9000	.0820	10.32	.0100	.0004	.62	6,840
						30,	1.8000	.0840	8.42	.0200	.0007	.63	6,390
Feb 7,	11,429	46°	37°	-	3½	Feb. 3,	1.9000	.0700	6.54	.0100	.0006	.64	4,320
						6,	1.9000	.0820	6.15	.0100	.0005	.63	6,120
14,	8,571	45°	37°	-	3¾	10,	1.6000	.0800	6.42	.0100	.0010	.70	4,200
						13,	1.9000	.0820	6.00	.0100	.0001	.73	160
21,	8,571	45°	38°	-	4½	20,	2.0000	.0800	5.14	.0100	.0012	.71	5,460
28,	8,571	45°	38°	-	2	27,	1.9000	.0760	4.94	.0100	.0014	.72	260
March 7,	7,143	44°	37°	-	3	March 6,	1.8000	.0840	5.19	.0100	.0014	.72	960
14,	4,286	45°	39°	-	0	13,	1.9000	.0560	4.80	.0070	.0018	.57	3,600

Sewage applied 6 times a week through January; 3 times, February to April; none applied in May, and afterwards applied 6 times a week.

Surface raked (or picked) about 1 inch deep each week.

Snow and ice removed from surface December 11, 16, 18, 27, January 2, 5, 6, 10, February 9, 10, 21, 27, and March 5.

Experiments interrupted by high water in the river January 25 and 26.

Effluent clear until December 1; afterwards slightly turbid.

FILTER TANK NO. 3 A — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Mar. 21,	4,286	45°	39°	-	¾	Mar. 20,	1.8000	.0400	3.72	.0600	.0060	.42	1,040
28,	1,429	37°	39°	-	0	-	-	-	-	-	-	-	-
April 4,	4,286	46°	41°	-	0	31,	1.9600	.0420	4.50	.1700	.0050	.32	3
						April 3,	1.7000	.0700	4.50	.1900	.0034	.30	340
11,	4,286	45°	42°	-	0	10,	1.7000	.0400	4.27	.4200	.0036	.32	2,400
18,	1,429	46°	46°	-	-	-	-	-	-	-	-	-	-
25,	4,286	51°	49°	-	-	24,	1.9600	.0480	3.57	.3500	.0040	.28	780
May 2,	2,857	50°	50°	-	-	May 1,	1.1000	.0420	3.32	.7000	.0040	.26	380
9,	0	-	50°	-	-	8,	1.0600	.0320	3.22	.8000	.0032	.28	560
16,	0	-	53°	-	-	15,	1.0400	.0420	3.05	.5000	.0080	.23	740
23,	0	-	55°	-	-	22,	.9000	.0240	2.98	.3400	.0090	.28	25
30,	0	-	57°	-	-	29,	.8000	.0480	2.83	.3700	.0600	.30	90
June 6,	8,571	62°	59°	-	-	June 5,	.9000	.0460	2.98	.2300	.0200	.31	10
13,	8,571	64°	62°	-	-	12,	.7400	.0420	3.18	.9200	.0340	.49	5
20,	8,571	68°	63°	-	-	19,	1.1000	.0480	3.43	1.1200	.0400	.45	5
27,	7,143	67°	64°	-	-	26,	1.2400	.0740	4.44	3.4700	.1100	.48	0
July 4,	8,571	66°	64°	-	-	July 3,	.8500	.0520	6.14	4.0300	.1200	.57	540
11,	8,571	67°	65°	-	-	10,	1.1000	.0440	7.65	3.6500	.0400	.35	82
18,	8,571	72°	69°	-	-	17,	.9000	.0340	8.34	3.5700	.1000	.38	12
25,	8,571	72°	69°	-	-	24,	1.1000	.0540	9.15	4.2900	.1000	.38	70
Aug. 1,	8,571	70°	69°	-	-	31,	1.2600	.0460	9.14	6.0000	.0450	.34	9
8,	5,714	69°	69°	-	-	Aug. 7,	.8500	.0400	9.68	5.6400	.0600	.41	30
15,	0	-	72°	-	-	14,	.1100	.0260	9.82	5.1000	.0800	.32	5
22,	0	-	72°	-	-	-	-	-	-	-	-	-	-
29,	25,714	71°	72°	-	-	28,	1.3600	.0560	9.40	3.5000	.0220	.30	22
Sept. 5,	51,428	67°	70°	-	-	Sept. 1,	.4400	.0340	8.00	4.1100	.1500	.33	36,190
						4,	.1260	.0300	7.48	3.4200	.0600	.24	11,760
12,	51,428	66°	69°	-	-	8,	.0080	.0170	7.56	2.2700	.0160	.23	954
						11,	.1560	.0320	8.30	2.2300	.0240	.18	8,100
19,	51,428	67°	69°	-	-	15,	.0260	.0100	7.28	2.2700	.0060	.17	2,400
						18,	.0180	.0120	7.28	1.8400	.0024	.15	720

Sewage applied 6 times a week.

Surface raked about 1 inch deep each week.

August 26, coarse sand removed from tank, surface of fine sand spaded up to a depth of 4 to 5 inches deep and coarse sand replaced dry.

Experiments interrupted by high water in the river March 14-16 and 23-27.

Effluent clear and practically colorless.

FILTER TANK NO. 3 A — *Concluded.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Sept. 26,	51,428	69°	70°	-	-	Sept. 22,	.0022	.0118	9.72	2.5100	.0007	.18	162
						25,	.0042	.0122	9.52	2.9800	.0012	.13	1,130
Oct. 3,	51,428	67°	71°	-	-	Oct. 2,	.0242	.0144	10.46	3.0600	.0018	.15	3,600
10,	51,428	63°	69°	-	-	9,	.0132	.0128	8.16	3.2000	.0014	.14	50
17,	51,428	55°	61°	-	-	16,	.0012	.0144	8.02	1.6700	.0080	.16	19,440
24,	51,428	51°	59°	-	-	23,	.0070	.0104	6.86	1.8500	.0004	.18	138
31,	42,857	45°	55°	-	-	30,	.0102	.0096	7.10	1.6600	.0012	.10	280
Nov. 7,	51,428	44°	51°	-	-	Nov. 6,	.0140	.0116	8.48	1.9700	.0036	.18	512
14,	51,428	44°	50°	-	-	13,	.2200	.0180	9.07	2.5700	.0300	.16	570
21,	51,428	43°	49°	-	-	20,	.0700	.0200	9.72	3.2400	.0060	.12	128
28,	51,428	42°	45°	-	1	27,	.1400	.0200	7.37	2.7300	.0200	.14	570
Dec. 5,	51,428	39°	47°	44m.	2½	Dec. 4,	.1200	.0180	6.35	1.9500	.0008	.21	33
12,	51,428	43°	45°	-	0	11,	.1600	.0260	7.08	2.3000	.0090	.19	1,700
19,	51,428	46°	43°	-	3	18,	.1600	.0140	8.32	1.3690	.0050	.15	39
26,	51,428	45°	43°	-	1	24,	.0420	.0120	7.29	1.6400	.0006	.12	19

Sewage applied 6 times a week. Surface raked 1 inch deep each week.
Effluent clear and practically colorless.

Chemical and Biological Examinations of Effluent representing Different Parts of the Daily Flow of Filter Tank No. 3 A.

Day.	Hour.	Rate of Flow. Cubic Centimeters per Minute.	Amount Passed Since Flooding. Gallons.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.										
May 8,	9.15	208	0	.8000	.0500	4.39	2.7500	.0200	.12	1,836
8,	11.08	240	6	.8200	.0800	4.39	3.0000	.0140	.13	1,404
8,	2.42	640	34	.8000	.0800	4.34	2.7500	.0120	.14	6,318
8,	5.24	560	64	.8500	.0500	4.36	3.0000	.0180	.11	12,204
8,	8.45	440	89	.8500	.0500	4.39	2.7500	.0220	.12	1,026

May 8. — Sewage equivalent to 30,000 gallons per acre applied from 9.37 to 9.48.

July 24,	9.16	192	0	.0088	.0106	8.62	1.6000	.0004	.07	123
24,	10.38	4,950	20	.0028	.0126	8.85	1.6000	.0006	.06	53
24,	10.50	5,430	40	.0030	.0140	8.84	1.5000	.0004	.06	181
24,	11.05	4,980	60	.0030	.0106	8.70	1.7500	.0010	.06	212
24,	11.37	3,920	100	.0040	.0096	8.50	1.8000	.0002	.07	330
24,	2.50	1,080	200	.0056	.0114	8.08	1.6000	.0020	.07	57

July 24. — Sewage equivalent to 60,000 gallons per acre applied from 9.31 to 9.53.

The following is a summary of twenty-four microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 3 A.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Fungi. Molds,	4	17	425
ANIMALS.			
Infusoria.			
Monas,	32	30	175
Paramæcium,	24	200	3,900
Vorticella,	8	5	100
Unclassified,	4	1	5

FILTER TANK No. 4.

This large tank is filled with very fine sand, the mechanical analysis of which was given on page 429. In it is a trench two feet wide and one foot deep, filled with No. 1 sand, the surface of which is two inches below the surface of the fine sand. This coarse sand, occupying one-third of the total area, receives all the sewage, but the quantity applied is reckoned on the total area of the filter. The earlier history of the filter was given in the special report upon the Purification of Sewage and Water (page 303).

Commencing Jan. 30, 1890, the surface of the coarse sand has been raked each week; the fine sand has remained undisturbed except that the heavy grass which grew upon it has been cut. A canvas cover sheltered the filter during the winter of 1889–90 but the following season the surface was exposed to the weather. Snow was promptly removed and the ice and frost broken when necessary. Sewage was applied at a temperature of 44°–46°.

After introducing the trench of coarse sand June 24, 1889, the dose of sewage was 12,800 gallons per acre daily, with which excellent results were obtained. On August 30 the quantity applied was increased to 25,600 gallons, with which uniformly

good results were obtained for a year. On Sept. 8, 1890, the quantity was again increased to 34,200 gallons, which the filter continued to receive with good results until Nov. 11, 1891, when the dose was further increased to 42,800 gallons per acre daily. Owing to the frost, nitrification was slightly interrupted in the winter of 1890–91 but the effect of the frost came later and was less marked than with the filters of coarse materials. The worst result, all things considered, was in March, when the free ammonia was .1950 and the nitrates .59 part per 100,000; the albuminoid ammonia was .0270, or 4.3 per cent. of that of the sewage, and the oxygen consumed was .23, or 8 per cent. The number of bacteria remained low, averaging 15 for the month.

The average work of the filter since sewage was first applied, January, 1888, is represented in the following table of averages for the most important periods: —

Average Results of Analyses of Sewage and Effluent of Filter Tank No 4.

		Quantity Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January—April, 1888,	Sewage,	39,400	1.0272	.5821	2.63	0	0	-	1,189,339
	Effluent,	37,200	.1759	.0205	2.70	.02	.0005	-	2,362
May—December, 1888,	Sewage,	17,200	1.8824	.7831	5.61	0	0	-	884,111
	Effluent,	18,400	.3773	.0419	5.59	.32	.0029	-	24
January—October, 1889,	Sewage,	15,500	1.7279	.4763	4.84	0	0	-	780,732
	Effluent,	16,000	.0123	.0128	4.14	.52	.0003	-	40
November, 1889—August, 1890,	Sewage,	25,600	1.7500	.6500	5.54	0	0	3.02	850,000
	Effluent,	23,600	.0017	.0120	5.36	1.33	.0001	.18	184
September—December, 1890,	Sewage,	34,200	1.8900	.6900	5.23	0	0	3.61	1,186,000
	Effluent,	33,400	.0016	.0122	6.88	1.10	0	.14	431
January—May, 1891,	Sewage,	34,200	1.5200	.5600	4.93	0	0	2.65	613,000
Cold weather, unprotected,	Effluent,	35,600	.1348	.0202	4.19	1.02	.0017	.20	49
June—December, 1891,	Sewage,	36,400	2.7200	.8500	9.11	0	0	4.35	751,222
Warm weather,	Effluent,	35,200	.0033	.0117	6.64	1.76	.0002	.15	50

The weekly analyses are given in full in the following table: —

Filter Tank No. 4.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.				Free.	Albuminoid.		Nitrates.	Nitrites.		
1889.													
Nov. 9,	25,714	48°	53°	1h.39m.	-	Nov. 7,	.0018	.0118	4.42	1.1500	.0000	-	420
16,	25,714	47°	52°	2h.	-	14,	.0002	.0086	4.59	1.2000	.0000	-	6
23,	25,714	44°	50°	-	-	21,	.0014	.0092	4.34	1.3600	.0001	-	134
30,	25,714	43°	48°	-	-	28,	.0006	.0072	5.25	1.4600	.0008	-	58
Dec. 7,	25,714	40°	46°	-	1¼	Dec. 5,	.0002	.0078	5.00	1.5000	.0001	-	49
14,	25,714	39°	45°	-	-	12,	.0002	.0106	4.52	1.0000	.0000	-	-
21,	25,714	45°	43°	2h.30m.	¼	19,	.0004	.0102	4.27	1.0000	.0000	-	17
28,	25,714	45°	43°	-	1	26,	.0008	.0088	3.99	1.5000	.0002	-	6
1890.													
Jan. 4,	25,714	45°	43°	-	-	Jan. 2,	.0026	.0126	4.47	1.1000	.0004	-	11
11,	25,714	45°	42°	2h.48m.	1	9,	.0016	.0084	5.12	1.0000	.0000	-	20
18,	25,714	45°	41°	2h.51m.	1¼	16,	.0046	.0098	7.00	1.0000	.0022	-	-
25,	25,714	45°	40°	-	-	23,	.0004	.0102	6.19	.8000	.0002	-	-
Feb. 1,	25,714	44°	39°	-	2	29,	.0006	.0092	5.05	.9000	.0000	-	101
8,	25,714	44°	39°	-	2	Feb. 5,	.0018	.0102	4.37	.9000	.0000	-	50
15,	25,714	44°	39°	-	-	12,	.0010	.0094	4.27	1.0000	.0000	-	620
22,	25,714	45°	38°	3h.30m.	1½	19,	.0016	.0116	3.87	1.0500	.0000	-	-
Mar. 1,	25,714	44°	38°	3h.8m.	-	26,	.0026	.0122	4.05	1.1000	.0000	-	84
8,	25,714	45°	38°	2h.37m.	1½	Mar. 5,	.0028	.0132	4.42	1.1000	.0000	.11	5
15,	25,714	45°	39°	-	-	12,	.0032	.0124	3.88	1.1000	.0000	.12	141
22,	25,714	44°	40°	-	¾	19,	.0036	.0126	3.79	1.3000	.0000	.14	5
29,	25,714	45°	39°	3h.2m.	-	26,	.0032	.0132	4.37	1.4000	.0000	-	60
Apr. 5,	25,714	46°	40°	2h.54m.	-	Apr. 2,	.0030	.0132	4.29	1.6000	.0000	.11	27
12,	25,714	45°	40°	3h.30m.	-	9,	.0014	.0128	4.34	1.4000	.0000	.13	10
19,	25,714	46°	43°	2h.7m.	-	16,	.0030	.0120	4.42	1.5000	.0000	.11	18
26,	25,714	47°	44°	2h.15m.	-	23,	.0006	.0138	4.22	2.2500	.0000	.11	14
May 3,	25,714	48°	46°	-	-	30,	.0014	.0108	4.22	2.2500	.0000	.12	81
10,	25,714	52°	49°	-	-	May 7,	.0004	.0102	4.65	2.2500	.0000	.13	8
17,	25,714	56°	53°	1h.31m.	-	14,	.0016	.0116	4.73	2.5000	.0001	.12	1,040
24,	25,714	58°	55°	2h.	-	21,	.0014	.0126	3.94	2.2500	.0000	.13	-
31,	25,714	58°	56°	-	-	28,	.0018	.0146	4.14	1.8000	.0000	.13	0

Sewage applied 3 times a week.
Surface protected by canvas cover from November 27 to April 8.
November 15, grass on coarse sand pulled up.
February 18, surface of coarse sand raked and levelled.
Effluent clear and practically colorless.

FILTER TANK NO. 4 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
June 7,	25,714	61°	57°	-	-	June 4,	.0024	.0146	4.80	2.2500	.0000	.13	19
14,	25,714	62°	58°	1h. 18m.	-	11,	.0016	.0122	5.02	1.4000	.0000	.14	8,614
21,	25,714	64°	60°	-	-	18,	.0026	.0132	4.62	1.0000	.0000	.16	213
28,	25,714	70°	61°	-	-	25,	.0014	.0138	4.88	.6500	.0000	.14	10
July 5,	25,714	71°	63°	1h. 30m.	-	July 2,	.0028	.0148	4.82	1.0000	.0000	.14	559
12,	25,714	73°	65°	-	-	9,	.0016	.0104	6.56	1.0000	.0000	.09	3
19,	25,714	73°	66°	1h.	-	16,	.0016	.0130	7.40	1.1000	.0000	.14	1
26,	25,714	70°	66°	-	-	23,	.0010	.0132	7.84	1.0000	.0000	.14	1
Aug. 2,	25,714	72°	69°	-	-	30,	.0022	.0154	9.54	1.0000	.0000	.14	72
9,	25,714	77°	69°	45m.	-	Aug. 6,	.0016	.0152	9.34	1.0000	.0000	.16	15
16,	25,714	73°	69°	1h.	-	13,	.0018	.0148	7.94	1.3500	.0000	.19	94
23,	25,714	77°	69°	-	-	20,	.0024	.0196	8.77	1.3500	.0000	.15	17
30,	25,714	68°	69°	41m.	-	27,	.0018	.0174	11.88	1.4000	.0004	.09	54
Sept. 6,	25,714	66°	66°	-	-	Sept. 3,	.0026	.0144	10.95	1.2000	.0000	.06	-
13,	34,286	68°	67°	1h. 15m.	-	10,	.0022	.0162	9.32	1.2500	.0000	.18	-
20,	34,286	66°	67°	-	-	17,	.0008	.0124	6.23	1.2500	.0000	.20	-
27,	34,286	63°	66°	1h.	-	24,	.0014	.0138	5.68	1.2500	.0002	.22	56
Oct. 4,	34,286	60°	64°	-	-	Oct. 1,	.0012	.0140	5.20	.7500	.0001	-	39
11,	34,286	59°	62°	-	-	8,	.0006	.0110	5.94	1.2000	.0000	.19	36
18,	34,286	54°	60°	-	-	15,	.0006	.0104	5.66	.9000	.0000	.19	12
25,	34,286	47°	57°	-	-	24,	.0022	.0136	7.67	1.0000	.0000	.09	3
Nov. 1,	34,286	47°	54°	-	-	29,	.0012	.0110	4.62	.7000	.0000	.18	103
8,	34,286	45°	52°	-	-	Nov. 5,	.0008	.0106	5.32	.7400	.0000	.11	164
15,	34,269	45°	51°	2h. 30m.	-	12,	.0010	.0118	6.02	1.1500	.0000	.12	7
22,	34,286	43°	49°	-	1¼	19,	.0008	.0086	5.57	1.2900	.0000	.12	6
29,	34,286	39°	48°	-	4	26,	.0008	.0106	5.30	1.1500	.0000	.14	4
Dec. 6,	34,286	42°	44°	-	5	Dec. 3,	.0004	.0098	5.27	1.4800	.0000	.10	0
13,	34,286	45°	42°	-	4	10,	.0004	.0122	9.32	1.3500	.0001	.11	6,240
20,	34,286	44°	41°	12h.	6	17,	.0010	.0116	11.35	1.0700	.0001	.13	76
27,	34,286	45°	41°	-	6	24,	.0098	.0148	6.42	.7700	.0000	.20	28
1891.													
Jan. 3,	34,286	44°	40°	-	5¼	Jan. 2,	.0284	.0124	4.82	1.0200	.0000	.19	18
10,	34,286	44°	39°	-	6¼	9,	.0352	.0156	4.63	.8600	.0003	.18	16

Sewage applied 3 times a week. Surface of coarse sand raked about 1 inch deep each week.

October 27, grass on fine sand cut down.

Snow and ice removed from surface of the coarse sand and piled upon the fine sand December 11, 12, 18, 29, and January 7.

Effluent clear and practically colorless.

FILTER TANK NO. 4.

Week Ending—	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.													
Nov. 9,	25,714	48°	53°	1h. 39m.	-	Nov. 7,	.0018	.0118	4.42	1.1500	.0000	-	420
16,	25,714	47°	52°	2h.	-	14,	.0002	.0086	4.59	1.2000	.0000	-	6
23,	25,714	44°	50°	-	-	21,	.0014	.0092	4.34	1.3600	.0001	-	134
30,	25,714	43°	48°	-	-	28,	.0006	.0072	5.25	1.4600	.0008	-	58
Dec. 7,	25,714	40°	46°	-	1¼	Dec. 5,	.0002	.0078	5.00	1.5000	.0001	-	49
14,	25,714	39°	45°	-	-	12,	.0002	.0106	4.52	1.0000	.0000	-	-
21,	25,714	45°	43°	2h. 30m.	¼	19,	.0004	.0102	4.27	1.0000	.0000	-	17
28,	25,714	45°	43°	-	1	26,	.0008	.0088	3.99	1.5000	.0002	-	6
1890.													
Jan. 4,	25,714	45°	43°	-	-	Jan. 2,	.0026	.0126	4.47	1.1000	.0004	-	11
11,	25,714	45°	42°	2h. 48m.	1	9,	.0016	.0084	5.12	1.0000	.0000	-	20
18,	25,714	45°	41°	2h. 51m.	1¼	16,	.0046	.0098	7.00	1.0000	.0022	-	-
25,	25,714	45°	40°	-	-	23,	.0004	.0102	6.19	.8000	.0002	-	-
Feb. 1,	25,714	44°	39°	-	2	29,	.0006	.0092	5.05	.9000	.0000	-	101
8,	25,714	44°	39°	-	2	Feb. 5,	.0018	.0102	4.37	.9000	.0000	-	50
15,	25,714	44°	39°	-	-	12,	.0010	.0094	4.27	1.0000	.0000	-	620
22,	25,714	45°	38°	3h. 30m.	1½	19,	.0016	.0116	3.87	1.0500	.0000	-	-
Mar. 1,	25,714	44°	38°	3h. 8m.	-	26,	.0026	.0122	4.05	1.1000	.0000	-	84
8,	25,714	45°	38°	2h. 37m.	1½	Mar. 5,	.0028	.0132	4.42	1.1000	.0000	.11	5
15,	25,714	45°	39°	-	-	12,	.0032	.0124	3.88	1.1000	.0000	.12	141
22,	25,714	44°	40°	-	¾	19,	.0036	.0126	3.79	1.3000	.0000	.14	5
29,	25,714	45°	39°	3h. 2m.	-	26,	.0032	.0132	4.37	1.4000	.0000	-	60
Apr. 5,	25,714	46°	40°	2h. 54m.	-	Apr. 2,	.0030	.0132	4.29	1.6000	.0000	.11	27
12,	25,714	45°	40°	3h. 30m.	-	9,	.0014	.0128	4.34	1.4000	.0000	.13	10
19,	25,714	46°	43°	2h. 7m.	-	16,	.0030	.0120	4.42	1.5000	.0000	.11	18
26,	25,714	47°	44°	2h. 15m.	-	23,	.0006	.0138	4.22	2.2500	.0000	.11	14
May 3,	25,714	48°	46°	-	-	30,	.0014	.0108	4.22	2.2500	.0000	.12	81
10,	25,714	52°	49°	-	-	May 7,	.0004	.0102	4.65	2.2500	.0000	.13	8
17,	25,714	56°	53°	1h. 31m.	-	14,	.0016	.0116	4.73	2.5000	.0001	.12	1,040
24,	25,714	58°	55°	2h.	-	21,	.0014	.0126	3.94	2.2500	.0000	.13	-
31,	25,714	58°	56°	-	-	28,	.0018	.0146	4.14	1.8000	.0000	.13	0

Sewage applied 3 times a week.
Surface protected by canvas cover from November 27 to April 8.
November 15, grass on coarse sand pulled up.
February 18, surface of coarse sand raked and levelled.
Effluent clear and practically colorless.

FILTER TANK NO. 4 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
June 7,	25,714	61°	57°	-	-	June 4,	.0024	.0146	4.80	2.2500	.0000	.13	19
14,	25,714	62°	58°	1h. 18m.	-	11,	.0016	.0122	5.02	1.4000	.0000	.14	8,614
21,	25,714	64°	60°	-	-	18,	.0026	.0132	4.62	1.0000	.0000	.16	213
28,	25,714	70°	61°	-	-	25,	.0014	.0138	4.88	.6500	.0000	.14	10
July 5,	25,714	71°	63°	1h. 30m.	-	July 2,	.0028	.0148	4.82	1.0000	.0000	.14	559
12,	25,714	73°	65°	-	-	9,	.0016	.0104	6.56	1.0000	.0000	.09	3
19,	25,714	73°	66°	1h.	-	16,	.0016	.0130	7.40	1.1000	.0000	.14	1
26,	25,714	70°	66°	-	-	23,	.0010	.0132	7.84	1.0000	.0000	.14	1
Aug. 2,	25,714	72°	69°	-	-	30,	.0022	.0154	9.54	1.0000	.0000	.14	72
9,	25,714	77°	69°	45m.	-	Aug. 6,	.0016	.0152	9.34	1.0000	.0000	.16	15
16,	25,714	73°	69°	1h.	-	13,	.0018	.0148	7.94	1.3500	.0000	.19	94
23,	25,714	77°	69°	-	-	20,	.0024	.0196	8.77	1.3500	.0000	.15	17
30,	25,714	68°	69°	41m.	-	27,	.0018	.0174	11.88	1.4000	.0004	.09	54
Sept. 6,	25,714	66°	66°	-	-	Sept. 3,	.0026	.0144	10.95	1.2000	.0000	.06	-
13,	34,286	68°	67°	1h. 15m.	-	10,	.0022	.0162	9.32	1.2500	.0000	.18	-
20,	34,286	66°	67°	-	-	17,	.0008	.0124	6.23	1.2500	.0000	.20	-
27,	34,286	63°	66°	1h.	-	24,	.0014	.0138	5.68	1.2500	.0002	.22	56
Oct. 4,	34,286	60°	64°	-	-	Oct. 1,	.0012	.0140	5.20	.7500	.0001	-	39
11,	34,286	59°	62°	-	-	8,	.0006	.0110	5.94	1.2000	.0000	.19	36
18,	34,286	54°	60°	-	-	15,	.0006	.0104	5.66	.9000	.0000	.19	12
25,	34,286	47°	57°	-	-	24,	.0022	.0136	7.67	1.0000	.0000	.09	8
Nov. 1,	34,286	47°	54°	-	-	29,	.0012	.0110	4.62	.7000	.0000	.18	103
8,	34,286	45°	52°	-	-	Nov. 5,	.0008	.0106	5.32	.7400	.0000	.11	164
15,	34,269	45°	51°	2h. 30m.	-	12,	.0010	.0118	6.02	1.1500	.0000	.12	7
22,	34,286	43°	49°	-	1½	19,	.0008	.0086	5.57	1.2900	.0000	.12	6
29,	34,286	39°	48°	-	4	26,	.0008	.0106	5.30	1.1500	.0000	.14	4
Dec. 6,	34,286	42°	44°	-	5	Dec. 3,	.0004	.0098	5.27	1.4800	.0000	.10	0
13,	34,286	45°	42°	-	4	10,	.0004	.0122	9.32	1.3500	.0001	.11	6,240
20,	34,286	44°	41°	12h.	6	17,	.0010	.0116	11.35	1.0700	.0001	.13	76
27,	34,286	45°	41°	-	6	24,	.0098	.0148	6.42	.7700	.0000	.20	28
1891.													
Jan. 3,	34,286	44°	40°	-	5½	Jan. 2,	.0284	.0124	4.82	1.0200	.0000	.19	18
10,	34,286	44°	39°	-	6¼	9,	.0352	.0156	4.63	.8600	.0003	.18	16

Sewage applied 3 times a week. Surface of coarse sand raked about 1 inch deep each week.

October 27, grass on fine sand cut down.

Snow and ice removed from surface of the coarse sand and piled upon the fine sand December 11, 12, 18, 29, and January 7.

Effluent clear and practically colorless.

FILTER TANK NO. 4 — *Continued.*

Week Ending —	Quantity Applied — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Jan. 17,	22,857	44°	38°	-	1	Jan. 16,	.0540	.0146	4.42	.6500	.0001	.21	-
24,	11,428	45°	39°	-	2	23,	.0800	.0220	3.68	.7100	.0003	.23	11
31,	11,428	44°	38°	-	7	30,	.0360	.0120	3.64	.7700	.0003	.19	32
Feb. 7,	34,286	42°	39°	-	½	Feb. 6,	.0960	.0220	2.90	.5600	.0009	.21	200
14,	34,286	45°	37°	-	½	13,	.0826	.0214	3.38	.4600	.0004	.25	164
21,	34,286	45°	37°	-	1½	19,	.1560	.0200	5.55	.3100	.0007	.24	200
28,	34,286	43°	37°	-	2	26,	.1700	.0300	4.54	.2900	.0024	.27	152
Mar. 7,	34,286	44°	37°	-	2½	Mar. 5,	.1500	.0400	4.14	.4300	.0008	.25	30
14,	22,857	45°	37°	-	0	12,	.1900	.0280	3.70	.6400	.0012	.25	3
21,	34,286	45°	38°	-	¼	19,	.2300	.0180	3.67	.5800	.0014	.24	20
28,	11,428	37°	38°	-	½	-	-	-	-	-	-	-	-
Apr. 4,	34,286	45°	39°	-	0	31,	.2100	.0220	3.27	.7000	.0014	.20	8
						Apr. 2,	.2200	.0520	3.27	.8000	.0030	.21	1
11,	34,286	45°	40°	-	0	9,	.3200	.0180	4.90	1.4400	.0044	.16	20
18,	11,428	46°	43°	-	-	-	-	-	-	-	-	-	-
25,	34,286	51°	46°	1h. 20m.	-	23,	.2400	.0080	5.00	1.4000	.0060	.11	6
May 2,	34,286	50°	49°	-	-	30,	.1800	.0160	4.72	2.1600	.0040	.15	84
9,	34,286	49°	50°	-	-	May 7,	.1260	.0140	4.68	2.1000	.0020	.14	10
16,	34,286	55°	53°	2h. 30m.	-	14,	.0760	.0120	4.60	1.7000	.0024	.15	5
23,	34,286	54°	53°	2h. 52m.	-	21,	.0428	.0084	4.77	1.9500	.0016	.17	2
30,	34,286	60°	55°	-	-	28,	.0196	.0136	3.85	1.6100	.0009	.18	6
June 6,	34,286	62°	58°	-	-	June 4,	.0178	.0136	4.10	2.0500	.0012	.18	5
13,	34,286	64°	61°	-	-	11,	.0028	.0116	4.33	1.6700	.0000	.13	10
20,	34,286	69°	61°	-	-	18,	.0012	.0118	4.13	1.3200	.0000	.14	16
27,	34,286	66°	61°	2h.	-	25,	.0038	.0122	6.40	1.9100	.0000	.17	0
July 4,	34,286	67°	64°	-	-	July 2,	.0014	.0136	6.25	1.9800	.0000	.17	0
11,	34,286	67°	63°	-	-	9,	.0008	.0120	5.75	1.9300	.0000	.15	2
18,	34,286	72°	66°	-	-	16,	.0010	.0110	9.33	1.7000	.0000	.18	2
25,	34,286	72°	64°	-	-	23,	.0004	.0134	7.25	2.2000	.0000	.14	-

Sewage applied 3 times a week.

Surface of coarse sand raked (or picked) about 1 inch deep each week.

Snow and ice removed from surface of the coarse sand and piled upon the fine sand January 14, 20, 26, February 6, 9, 21, 27, March 2 and 5.

Experiments interrupted by high water in the river January 25, 26, March 14-16, 23-27.

Effluent clear and practically colorless.

FILTER TANK No. 4 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Aug. 1,	34,286	67°	67°	-	-	July 30,	.0012	.0122	8.58	2.2000	.0001	.13	0
8,	34,286	70°	68°	-	-	Aug. 6,	.0014	.0132	7.58	2.5100	.0001	.12	216
15,	34,286	74°	70°	-	-	13,	.0008	.0136	6.92	2.1500	.0000	.15	1
22,	34,286	73°	70°	2h.	-	20,	.0006	.0116	6.30	1.9800	.0006	.20	6
29,	34,286	72°	70°	-	-	27,	.0006	.0114	6.41	2.3300	.0002	.15	8
Sept. 5,	34,286	67°	69°	-	-	Sept. 3,	.0002	.0122	6.34	2.0700	.0000	.13	3
12,	34,286	66°	68°	-	-	10,	.0010	.0118	7.91	1.6700	.0000	.12	0
19,	34,286	67°	66°	-	-	17,	.0014	.0116	10.28	1.1000	.0000	.17	13
26,	34,286	69°	67°	-	-	24,	.0018	.0120	8.20	1.5400	.0000	.18	4
Oct. 3,	34,286	68°	67°	-	-	Oct. 1,	.0018	.0123	6.80	1.9800	.0000	.14	1,300
10,	34,286	62°	66°	2h.	-	8,	.0010	.0108	7.00	1.9800	.0002	.14	5
17,	34,286	55°	61°	-	-	15,	.0024	.0098	8.88	1.6700	.0000	.13	6
24,	34,286	50°	60°	1h.	-	22,	.0008	.0094	7.50	2.1100	.0000	.12	2
31,	34,286	46°	56°	-	-	29,	.0004	.0094	6.18	1.6300	.0001	.13	21
Nov. 7,	34,286	43°	53°	-	-	Nov. 5,	.0006	.0078	6.20	1.5000	.0002	.12	2
14,	40,000	43°	51°	-	-	12,	.0002	.0082	6.17	2.1100	.0000	.12	1
21,	42,857	42°	50°	-	-	19,	.0006	.0090	6.94	1.2300	.0016	.09	21
28,	42,857	41°	48°	-	1	26,	.0016	.0136	6.38	1.8500	.0004	.17	0
Dec. 5,	42,857	36°	47°	12h.	2	Dec. 3,	.0034	.0124	5.80	1.6300	.0000	.10	4
12,	42,857	43°	46°	6h.	½	10,	.0092	.0124	5.55	.6900	.0006	.15	6
19,	42,857	45°	45°	7h. 16m.	1½	17,	.0120	.0134	4.92	.9000	.0001	.16	7
26,	42,857	45°	43°	-	0	24,	.0162	.0108	5.60	1.1300	.0002	.16	3
						31,	.0180	.0160	6.42	1.4600	.0002	.18	2

Sewage applied three times a week.
Surface of coarse sand raked about one inch deep each week.
Heavy growth of grass upon the fine sand.
Effluent clear and practically colorless.

The following table contains a summary of twenty-four microscopical examinations of the effluent:—

Microscopical Examination of Effluent of Filter Tank No. 4.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ.			
Chlorococcus,	4	4	100
Ulothrix,	4	1	25
Fungi.			
Molds,	4	2	50
Saccharomyces,	4	208	5,000
ANIMALS.			
Infusoria.			
Monas,	8	60	900
Paramæcium,	4	1	25
Vermes.			
Anguillula,	8	2	25
Rotatorian ova,	8	2	25
Miscellaneous. Starch,	4	1	25

FILTER TANK No. 5.

The soil of which this filter was composed was so fine that it kept itself always saturated with water, almost completely excluding air. The results obtained up to October, 1890, were most unsatisfactory both as to quantity and quality of effluent; they have been already discussed in the report upon Purification of Sewage and Water (pages 356 and 682). Owing to the exclusion of air from the pores of the filter, the sewage was not oxidized as with the more open materials, but was merely strained, resulting in the removal of the insoluble organic matters and of the bacteria. Owing to deficiency of oxygen, large amounts of iron were taken into solution from the soil by the passing sewage, and the effluent was uniformly of a deep red color rapidly depositing ferric oxide on exposure to the air. The filter was continued in operation up to August 24, 1891, but as no improvement was noticed it need not be discussed further.

The average results for 1888 and 1889, with the monthly averages of results from November, 1889, are as follows:—

FILTER TANK NO. 5.

Month.	Quantity Applied. Gallons per Acre Daily.	Temperature.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Free.	Albuminoid.		Nitrates.	Nitrites.		
1888.										
Jan.—Dec.,	17,600	-	-	1.2937	.2281	5.27	.0200	.0002	-	818
1889.										
Jan.—Dec.,	7,200	-	-	3.2630	.2968	4.37	.0000	.0000	-	17
November,	8,571	46°	51°	4.6125	.2025	5.84	.0000	.0000	-	8
December,	8,571	42°	44°	3.3375	.1975	5.26	.0000	.0000	-	10
1890.										
January,	8,571	45°	42°	2.5800	.1320	5.94	.0000	.0000	-	9
February,	8,571	45°	40°	2.2125	.1350	5.61	.0000	.0000	-	8
March,	8,571	45°	40°	2.1500	.1425	4.36	.0000	.0000	1.97	9
April,	8,571	46°	43°	1.9700	.1580	4.23	.0000	.0000	1.80	32
May,	8,571	56°	53°	2.0875	.1675	4.30	.0000	.0000	1.92	105
June,	8,571	65°	60°	2.3125	.1625	4.58	.0000	.0000	2.22	194
July,	8,571	72°	68°	2.7000	.2780	4.93	.0000	.0000	2.66	702
August,	8,571	72°	70°	3.3875	.2525	5.70	.0000	.0000	3.17	28
September,	8,571	65°	66°	3.7500	.2275	7.89	.0000	.0000	3.02	40
October,	5,161	56°	58°	3.4375	.1875	7.36	.0000	.0000	3.50	272
November,	4,285	44°	50°	3.0875	.1775	5.53	.0000	.0000	2.92	108
December,	4,285	44°	44°	2.5375	.1650	5.25	.0000	.0000	2.62	12
1891.										
January,	1,936	45°	43°	2.3500	.1680	4.63	.0000	.0000	2.44	48
February,	1,071	44°	40°	2.1750	.1450	5.61	.0000	.0000	1.95	120
March,	1,071	45°	39°	2.0333	.1267	3.97	.0000	.0000	1.70	810
April,	2,333	48°	46°	2.0000	.1333	2.60	.0000	.0003	.71	54
May,	4,285	56°	54°	1.7800	.1100	2.15	.0000	.0008	1.62	168
June,	4,285	66°	61°	2.0500	.1675	2.32	.0000	.0000	2.47	30
July,	4,285	71°	68°	2.1125	.1775	2.14	.0000	.0000	2.87	14

Sewage applied 3 times a week.

Surface protected by canvas cover from Nov. 28, 1889, to April 8, 1890.

Surface of sand-ring raked about 1 inch deep each week, beginning July, 1890.

Snow and ice removed from surface of sand-ring Dec. 11, 12, 18, 29, 1890, and Jan. 5, 7, 21, 26, Feb. 9, 16, 21, March 2, 4, 5, 1891.

Experiments interrupted by high water in the river Oct. 21, 1890, Jan. 25, March 23 to 28, April 14 to 17, 1891.

July 13, 1891, grass on surface of the soil cut.

Effluent always discolored by iron, which, oxidizing in contact with the air, was deposited as a heavy red sediment. Odor decided or strong.

Summary of Seventeen Microscopical Examinations of Effluent of Filter Tank No. 5.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentages of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Fungi.			
Molds, ...	6	15	250
Saccharomyces, ...	12	80	800
ANIMALS.			
Infusoria.			
Monas, ...	12	80	1,200

FILTER TANK No. 5 A.

In September, 1891, the soil of Tank 5 was replaced by a sifted material somewhat coarser than No. 1 sand, and having the mechanical analysis given on page 429.

Commencing September 14, sewage was applied at the rate of 17,100 gallons per acre daily. The effluent contained nitrates from the beginning, and after four weeks there were 1.06 parts per 100,000. The quantity of sewage was then doubled and November 1 it was again increased to 200 gallons applied twice every week, day, equal to 68,000 gallons per acre daily. The chemical purification obtained during the following months was satisfactory, but the bacteria remained very high. The results are shown in the following table: —

Filter Tank No 5 A.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Sept. 19,	17,143	68°	67°	-	-	Sept. 15,	.2800	.0340	6.00	.4000	.0008	.31	3,100
						18,	.1360	.0260	1.37	.3700	.0036	.10	19,170
26,	17,143	69°	68°	-	-	22,	.2400	.0420	6.58	.2500	.0040	.42	52,326
						25,	.1360	.0280	3.80	.2300	.0070	.07	19,300
Oct. 3,	17,143	69°	67°	-	-	29,	.3800	.0260	8.18	.1300	.0180	.45	-
						Oct. 2,	.3200	.0460	7.50	.2000	.0150	.22	11,050
10,	17,143	64°	66°	-	-	6,	.8300	.0480	11.80	.4700	.0500	.29	54,000
						9,	.4300	.0540	8.70	1.0600	.1500	.59	34,000
17,	34,286	55°	59°	-	-	13,	.1240	.0340	8.65	.8600	.0100	.27	47,250
						16,	.1200	.0320	8.70	.8500	.0280	.22	49,930
24,	34,286	51°	57°	-	-	20,	.0340	.0160	7.05	1.3000	.0036	.08	58,230
						23,	.0560	.0300	7.55	1.5500	.0024	.21	74,925
31,	34,286	46°	54°	-	-	27,	.0400	.0400	7.03	1.3800	.0004	.37	2,264,000
						30,	.0330	.0142	6.70	1.2000	.0010	.07	531,000
Nov. 7,	68,571	44°	50°	-	1	Nov. 3,	.0280	.0180	7.43	1.6500	.0022	.06	350,000
						6,	.0520	.0180	8.25	.9300	.0007	.17	370,000
14,	68,571	43°	49°	-	-	10,	.0860	.0560	8.90	1.0300	.0018	.20	447,000
						13,	.3200	.0960	8.70	1.0000	.0080	.47	2,700,000
21,	68,571	43°	47°	-	2	17,	.3200	.0280	8.50	1.0100	.0060	.27	1,136,100
						20,	.1600	.0100	9.18	1.3200	.0004	.11	140,000
28,	62,857	43°	46°	-	1	24,	.2500	.0660	6.80	.8400	.0120	.53	510,000
						27,	.2000	.0220	6.15	.8600	.0030	.09	275,000
Dec. 5,	68,571	40°	44°	1h.	3	Dec. 1,	.5600	.0920	7.42	.3600	.0600	.73	280,000
						4,	.4000	.0440	6.84	.6300	.0026	.48	200,000
12,	68,571	44°	43°	-	1½	8,	.3600	.0520	6.48	.4000	.0044	.18	57,000
						11,	.3800	.0420	5.75	1.1800	.0050	.25	170,000
19,	68,571	45°	42°	-	4	15,	.5700	.0840	9.47	.8000	.0080	.69	147,000
						18,	.9000	.1200	7.55	.8500	.0050	1.26	163,000
26,	62,857	46°	43°	-	5	22,	.5200	.0440	9.63	1.1000	.0044	.17	127,000
						24,	.5700	.0700	7.32	1.1500	.0180	.39	93,600
						29,	.6500	.0440	8.80	1.6700	.0050	.26	22,200

Sewage applied 6 times a week from September 14 to October 11, and afterwards 12 times a week.
Surface raked about 1 inch deep each week.
Effluent somewhat turbid and with a slight odor, but colorless or nearly so.

Chemical and Biological Examinations of Effluent of Filter Tank No 5 A, representing the Different Parts of the Daily Flow.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.										
Sept. 25,	9.20	100	0	.1700	.0180	2.76	.3800	.0090	.06	7,080
25,	10.30	840	20	.1500	.0280	5.70	.1300	.0030	.11	111,600
25,	4.05	224	51	.1360	.0280	3.80	.2300	.0070	.07	19,800

September 25.—Sewage equivalent to 20,000 gallons per acre applied from 9.30 to 4.43.

Day.	Hour.	Rate of Flow.	Amount Passed since Flooding.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Dec. 2,	9.52	420	0	.1400	.0220	5.70	1.3000	.0012	.17	122,000
2,	11.31	1,080	48	.3500	.0380	7.33	.7700	.0010	.28	79,000
2,	4.23	2,280	100	.3700	.0600	6.92	.7900	.0010	.37	118,000
2,	6.50	1,960	196	.1800	.0300	6.30	1.3000	.0006	.19	105,300
3,	5.24	320	332	.1700	.0400	5.98	1.3600	.0012	.12	9,700

December 2.—Doses of sewage, each equivalent to 40,000 gallons per acre, applied from 9.27 to 9.51 and from 3.43 to 4.05.

FILTER TANK No. 6.

The earlier history of this large filter of mixed coarse and fine sand, 44 inches deep, was given in the report upon the Purification of Sewage and Water, pages 303 and 683. The mechanical analysis of the material is given on page 429 of this volume.

For the first three years, 1888–90, sewage was applied without disturbing the surface in any way. From November, 1889, to Sept. 6, 1890, sewage was applied at the rate of 42,600 gallons per acre daily, and since that date at the rate of 60,000 gallons. Commencing Jan. 1, 1891, the surface was raked each week, and through the winter snow was promptly removed from the surface. During the period of greatest cold, purification was checked in the same way as in the other filters to which sewage was applied over the whole area, and which were exposed to the weather, the worst results being obtained in February, when the effluent contained 12 per cent. both of the albuminoid ammonia and of the oxygen consumed of the sewage. Up to Feb. 14, 1889, the sewage was applied three times a week, but since that time half as much has been applied every week-day. The results since making this change have been on the whole slightly better than for corresponding periods during the previous year, especially with reference to bacteria, which averaged 10,000 per cubic centimeter for September to November, 1890, and only 1,477 during the summer of 1891. The change in the

method of applying the sewage having been made in winter, the immediate effect was obscured by complications due to cold.

Toward the close of the year 1891 the organic matters from the sewage retained in the upper layers had accumulated to such an extent as to seriously interfere with the ventilation of the filter, as described on page 438; and this, together with the frost, resulted in a rapid deterioration in the quality of the effluent in November and especially in December. The original power of the filter has since been restored by the removal of the clogged sand, two inches deep, and disturbing the sand for a considerable depth below the removed layer.

The work of the filter since sewage was first applied in January, 1888, is shown by the following table of averages for the principal periods. During the two periods from November, 1889, to November, 1890, at rates of 42,600 and 60,000 gallons per acre daily, respectively, the results obtained were most satisfactory, 97.5 per cent. of the albuminoid ammonia and 99.3 per cent. of the bacteria being removed. In the following period the results were less perfect, owing to the cold weather, as stated above; but with warm weather again, May to September, 1891, 97.3 per cent. of the albuminoid ammonia and 99.83 per cent. of the bacteria were removed. In the last period the reduction in the nitrification and the less complete purification are the results of the exclusion of air, due to clogging.

Average Results of Analyses of Sewage and Effluent of Filter Tank No. 6.

		Quantity Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January—April, 1888, . . .	Sewage,	33,200	.9678	.0209	2.61	0	0	-	1,189,449
	Effluent,	34,000	.2396	.0202	2.50	.02	.0005	-	8,815
May—December, 1888, . . .	Sewage,	34,200	1.8408	.7585	6.98	0	0	-	884,111
	Effluent,	36,000	.0160	.0093	5.80	1.05	.0028	-	143
January—October, 1889, . .	Sewage,	33,600	1.9504	.6097	4.98	0	0	-	680,732
	Effluent,	33,800	.0031	.0091	4.59	1.41	.0002	-	509
November, 1889—August, 1890, .	Sewage,	42,800	1.7500	.6500	5.54	0	0	3.02	850,000
	Effluent,	42,400	.0067	.0169	5.39	1.42	.0004	.10	5,831
September, 1890—November, 1890,	Sewage,	56,400	1.9800	.6900	5.16	0	0	3.56	1,290,000
	Effluent,	56,400	.0041	.0165	5.67	1.31	0	.11	10,000
December, 1890—April, 1891, .	Sewage,	52,400	1.4300	.5600	4.64	0	0	2.80	514,000
Cold weather, unprotected, . .	Effluent,	55,300	.3662	.0355	4.09	1.07	.0040	.24	13,300
May—September, 1891, . . .	Sewage,	58,600	2.5469	.7501	9.33	0	0	3.62	905,582
Warm weather, ...	Effluent,	-	.0013	.0198	9.25	1.96	.0005	.19	1,477
October—December, 1891, . .	Sewage,	42,400	2.7883	.9709	8.01	0	0	5.12	700,382
Beginning to be clogged, . .	Effluent,	42,600	.1045	.0353	8.31	.60	.0006	.38	3,963

The weekly analyses are given in full in the following table: —

Filter Tank No. 6.

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.													
Nov. 9,	42,857	48°	51°	-	-	Nov. 7,	.0014	.0114	4.59	1.7000	.0000	-	8,550
16,	42,857	47°	50°	1h.	-	14,	.0002	.0098	4.22	1.8000	.0000	-	1,932
23,	42,857	44°	48°	1h. 6m.	-	21,	.0124	.0098	4.80	1.3500	.0002	-	504
30,	42,857	42°	46°	-	-	28,	.0132	.0100	4.65	1.6000	.0008	-	825
Dec. 7,	42,857	39°	44°	-	1½	Dec. 5,	.0222	.0116	4.55	1.3500	.0012	-	451
14,	42,857	38°	42°	-	-	12,	.0572	.0158	3.90	1.3000	.0030	-	2,490
21,	42,857	44°	41°	1h. 11m.	0	19,	.0650	.0152	6.92	1.2000	.0040	-	8,448
28,	42,857	44°	41°	-	-	26,	.0068	.0116	4.55	1.4600	.0008	-	-
1890.													
Jan. 4,	42,857	44°	42°	-	-	Jan. 2,	.0058	.0152	4.37	1.0000	.0012	-	2,952
11,	42,857	44°	41°	-	2⅜	9,	.0036	.0152	4.15	.9000	.0008	-	5,600
18,	42,857	44°	40°	1h. 58m.	2⅞	16,	.0034	.0150	3.97	.9000	.0002	-	2,190
25,	42,857	45°	39°	-	-	23,	.0024	.0150	3.90	.8000	.0002	-	-
Feb. 1,	42,857	44°	37°	-	⅛	30,	.0064	.0168	4.54	1.2000	.0006	-	5,612
8,	42,857	45°	38°	-	1¼	Feb. 6,	.0062	.0198	5.70	.9500	.0004	-	7,040
15,	42,857	44°	38°	-	-	11,	.0030	.0172	4.34	.9500	.0004	-	3,762
						13,	.0024	.0148	4.05	1.1000	.0002	-	5,148
22,	42,857	44°	38°	1h. 30m.	⅜	20,	.0022	.0252	5.40	1.2000	.0002	-	-
March 1,	42,857	44°	38°	2h. 27m.	-	27,	.0024	.0184	3.84	1.0000	.0000	-	-
8,	42,857	45°	39°	-	-	March 6,	.0026	.0192	5.47	1.1000	.0000	.10	4,788
15,	42,857	44°	40°	-	-	13,	.0026	.0224	4.38	1.0000	.0000	.12	6,336
22,	42,857	44°	40°	-	0	20,	.0018	.0190	3.20	1.3000	.0000	.13	4,590
29,	42,857	45°	40°	4h.	-	27,	.0008	.0200	3.95	1.2000	.0000	.10	560
April 5,	42,857	45°	40°	-	-	April 3,	.0026	.0218	4.04	1.1000	.0000	.11	2,365
12,	42,857	44°	42°	7h. 57m.	-	10,	.0004	.0166	4.84	1.1000	.0000	.11	1,815
19,	42,857	45°	45°	3h. 39m.	-	17,	.0004	.0152	8.47	1.0000	.0000	.11	650
26,	42,857	47°	46°	-	-	24,	.0082	.0156	5.62	2.2000	.0002	.11	1,989
May 3,	42,857	50°	48°	5h. 1m.	-	May 1,	.0020	.0172	4.29	1.8000	.0000	.13	2,400
10,	42,857	53°	53°	-	-	8,	.0058	.0144	4.00	2.0000	.0000	.11	2,438
17,	42,857	56°	56°	-	-	15,	.0018	.0140	4.10	2.2500	.0002	.10	1,210
24,	42,857	58°	59°	-	-	22,	.0008	.0138	5.00	2.0000	.0000	.09	312
31,	42,857	58°	59°	-	-	29,	.0012	.0140	4.52	2 2500	.0000	.08	1,021

Sewage applied 3 times a week.
Surface protected by canvas cover from November 26 to April 8.
Effluent clear and colorless.

FILTER TANK NO. 6 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
June 7,	42,857	61°	59°	-	-	June 5,	.0004	.0130	5.14	1.5000	.0000	.09	-
14,	42,857	62°	60°	1h. 32m.	-	12,	.0006	.0122	4.74	1.0000	.0000	.10	2,280
21,	42,857	65°	62°	-	-	19,	.0038	.0146	4.12	1.4000	.0001	.08	5,605
28,	42,857	71°	64°	-	-	26,	.0016	.0138	5.37	1.5000	.0000	.10	767
July 5,	42,857	72°	66°	50m.	-	July 3,	.0008	.0184	7.31	1.2500	.0000	.12	-
12,	42,857	72°	68°	-	-	10,	.0016	.0236	7.34	1.7500	.0004	.10	12,036
19,	42,857	73°	67°	41m.	-	17,	.0014	.0190	7.94	1.5000	.0002	.10	18,900
26,	42,857	70°	67°	-	-	24,	.0010	.0182	8.51	1.5000	.0002	.11	16,992
Aug. 2,	42,857	73°	69°	-	-	31,	.0064	.0284	6.32	1.7500	.0012	.12	67,319
9,	42,857	77°	70°	-	-	Aug. 7,	.0008	.0194	9.58	1.1000	.0002	.12	32,627
16,	42,857	72°	70°	46m.	-	14,	.0034	.0256	9.12	1.9000	.0006	.12	36,720
23,	42,857	72°	70°	-	-	21,	.0038	.0146	9.82	2.3500	.0000	.09	6,000
30,	42,857	67°	68°	42m.	-	28,	.0024	.0174	6.96	2.2500	.0000	.08	-
Sept. 6,	42,857	66°	67°	-	-	Sept. 4,	.0148	.0160	8.29	2.0000	.0000	.08	481
13,	60,000	68°	67°	1h. 32m.	-	11,	.0034	.0136	7.59	1.8000	.0002	.07	6,785
20,	60,000	68°	68°	-	-	18,	.0012	.0136	5.40	1.1000	.0000	.10	-
27,	60,000	62°	65°	-	-	25,	.0022	.0162	5.60	1.2500	.0000	.10	17,280
Oct. 4,	60,000	60°	62°	1h. 20m.	-	Oct. 2,	.0022	.0180	6.65	1.4000	.0000	-	31,565
11,	51,428	58°	60°	-	-	9,	.0008	.0116	4.16	.9000	.0000	.10	2,760
18,	60,000	54°	58°	-	-	16,	.0030	.0152	5.67	.9000	.0000	.12	12,921
25,	40,000	49°	54°	-	-	23,	.0020	.0188	4.14	1.2500	.0000	.09	4,720
Nov. 1,	60,000	47°	51°	-	-	30,	.0004	.0164	5.10	.9000	.0000	.13	12,060
8,	60,000	46°	49°	-	-	Nov. 6,	.0042	.0152	5.80	1.5100	.0000	.13	11,322
15,	60,000	44°	48°	2h. 15m.	-	13,	.0024	.0212	5.24	1.0200	.0001	.14	4,020
22,	60,000	43°	46°	-	-	20,	.0020	.0214	4.14	1.4500	.0001	.14	14,040
29,	60,000	40°	45°	2h. 23m.	3⅝	27,	.0118	.0174	5.44	1.3600	.0003	.10	7,200
Dec. 6,	61,857	44°	41°	-	3	Dec. 4,	.0124	.0178	5.40	1.1700	.0003	.15	7,020
13,	60,000	45°	39°	-	9⅝	11,	.0320	.0202	4.25	.8700	.0006	.18	-
20,	60,000	44°	39°	12h.	10¼	18,	.0900	.0170	4.04	.8300	.0001	.21	5,060
27,	40,000	44°	39°	-	12¼	23,	.1200	.0260	3.24	.9400	.0150	.24	15,660
						27,	.1500	.0220	3.06	.8200	.0060	.18	6,000

Sewage applied 3 times a week.
December 23, surface raked about 1 inch deep.
Snow and ice removed from surface December 10, 12, 18 and 27.
Surface covered with grass from June 1 to October 27, when it was cut.
Experiments interrupted by high water in the river October 21 and 22.
Effluent clear and colorless.

FILTER TANK No. 6 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Jan. 3,	60,000	45°	38°	-	14½	Jan. 1,	.3500	.0260	4.17	.4800	.0016	.21	3,900
10,	60,000	45°	37°	-	13	6,	.6500	.0540	3.17	.3900	.0012	.48	22,140
						8,	.3300	.0380	3.15	.7200	.0030	.23	55,800
17,	60,000	44°	37°	-	7½	13,	.4500	.0400	2.34	.7500	.0060	.23	29,160
						15,	.4200	.0340	2.47	.2700	.0050	.15	32,400
24,	60,000	45°	37°	6h. 3m.	8	20,	.5600	.0400	2.92	.4800	.0020	.31	44,640
						22,	.3800	.0560	5.30	.5800	.0050	.45	12,960
31,	60,000	44°	36°	-	8	27,	1.0600	.0620	4.67	.3900	.0000	.40	28,980
						29,	.9400	.0540	4.25	.3200	.0036	.46	13,680
Feb. 7,	60,000	44°	37°	3h.	9	Feb. 3,	.8600	.0840	4.45	.7800	.0035	.34	43,200
						5,	.7600	.0660	4.52	.5700	.0036	.42	8,280
14,	60,000	45°	37°	4h.	13	10,	1.0000	.0600	6.04	.4600	.0040	.37	66,600
						12,	.7000	.0540	4.64	1.0000	.0040	.37	9,900
21,	60,000	45°	37°	-	7	17,	.8500	.0660	5.82	.5000	.0016	.41	12,240
						20,	.7500	.0420	2.82	.3500	.0012	.30	1,680
28,	50,000	44°	37°	-	5½	24,	.8500	.0260	7.30	.3600	.0016	.22	9,900
						27,	.3800	.0740	2.67	.6800	.0046	.35	28,800
Mar. 7,	60,000	44°	37°	-	5	Mar. 3,	.5000	.0400	2.87	.8800	.0024	.21	5,160
						6,	.5500	.0420	3.72	.6300	.0008	.22	9,720
14,	40,000	45°	37°	2h. 30m.	½	10,	.6000	.0340	3.78	.8900	.0028	.42	2,400
21,	50,000	45°	38°	-	1½	20,	.2400	.0320	3.20	.8600	.0024	.28	10,440
28,	0	-	38°	-	½	-	-	-	-	-	-	-	-
Apr. 4,	60,000	45°	41°	24m.	0	31,	.1460	.0220	3.35	2.4300	.0300	.16	2,460
						Apr. 3,	.1200	.0235	4.38	1.5300	.0080	.12	1,140
11,	60,000	45°	41°	35m.	-	7,	.0404	.0208	3.00	.7700	.0028	.10	8,280
						10,	.0242	.0254	4.67	1.4400	.0012	.14	8,640
18,	10,000	47°	46°	-	-	-	-	-	-	-	-	-	-
25,	60,000	52°	51°	33m.	-	21,	.0138	.0200	4.12	4.5000	.0003	.12	3,000
						24,	.0056	.0206	4.87	2.9300	.0000	.09	1,400

Sewage applied 3 times a week to February 14, and afterwards 6 times a week.

Surface raked (or picked) about one inch deep each week.

Snow and ice removed from surface January 6, 19, 26, February 10, 21, 27, March 2, 4, 5.

Experiments interrupted by high water in the river January 25, 26, February 27, 28, March 13-16, 23-28, and April 13-17.

Effluent somewhat turbid during January and February; very slightly turbid until April 10; afterwards clear and practically colorless.

FILTER TANK No. 6 — *Continued.*

WEEK ENDING —	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE. Sewage.	TEMPERATURE. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
May 2,	60,000	51°	52°	-	-	April 28,	.0100	.0198	6.62	1.9000	.0002	.12	5,040
						May 1,	.0018	.0190	6.12	1.3200	.0000	.19	1,500
9,	60,000	51°	51°	36m.	-	5,	.0008	.0196	7.44	1.8500	.0000	.13	2,940
						8,	.0018	.0166	6.45	1.2300	.0000	.14	900
16,	60,000	56°	55°	32m.	-	12,	.0022	.0192	5.28	1.6400	.0001	.12	2,580
						15,	.0008	.0222	8.22	1.5800	.0001	.18	9,000
23,	60,000	56°	57°	31m.	-	19,	.0008	.0210	4.48	1.5500	.0000	.20	2,760
						22,	.0014	.0204	9.63	2.1100	.0000	.15	7,140
30,	60,000	61°	60°	-	-	26,	.0018	.0256	8.18	1.8800	.0004	.19	14,400
						29,	.0012	.0220	6.48	1.8900	.0002	.21	1,320
June 6,	60,000	63°	62°	-	-	June 5,	.0022	.0234	7.10	1.9100	.0000	.19	1,840
13,	60,000	65°	64°	-	-	12,	.0006	.0188	7.50	2.3500	.0000	.17	307
20,	60,000	69°	67°	-	-	19,	.0012	.0240	15.53	2.1100	.0003	.19	78
27,	60,000	67°	66°	-	-	26,	.0006	.0148	8.54	1.6700	.0000	.19	17
July 4,	60,000	67°	67°	43m.	-	July 3,	.0018	.0168	10.88	2.2900	.0000	.16	440
11,	50,000	68°	67°	-	-	10,	.0010	.0186	7.20	2.8700	.0000	.15	1,720
18,	60,000	71°	72°	-	-	17,	.0008	.0218	10.58	2.4900	.0002	.21	-
25,	60,000	73°	71°	35m.	-	24,	.0010	.0216	11.35	2.2000	.0000	.21	2,680
Aug. 1,	50,000	69°	70°	40m.	-	31,	.0008	.0206	6.56	2.6400	.0000	.20	828
8,	60,000	70°	71°	-	-	Aug. 7,	.0018	.0190	13.39	2.3300	.0001	.13	70
15,	60,000	73°	73°	-	-	14,	.0018	.0274	13.05	2.2800	.0002	.22	20
22,	60,000	73°	73°	54m.	-	21,	.0012	.0170	13.32	1.4500	.0006	.19	900
29,	60,000	73°	73°	-	-	28,	.0016	.0212	9.16	1.5400	.0000	.24	261
Sept. 5,	60,000	68°	70°	1h. 11m.	-	Sept. 4,	.0014	.0184	12.10	1.5400	.0002	.18	744
12,	60,000	66°	68°	1h. 50m.	-	11,	.0010	.0144	6.33	2.3300	.0000	.21	312
19,	50,000	68°	68°	-	-	18,	.0010	.0156	5.63	1.9400	.0001	.24	270
26,	60,000	70°	69°	-	-	25,	.0016	.0204	8.35	1.1000	.0090	.22	144
Oct. 3,	60,000	68°	69°	-	-	Oct. 2,	.0018	.0242	13.64	.3900	.0000	.29	820
10,	60,000	64°	66°	3h. 30m.	-	7,	.0028	.0260	8.86	.7600	.0005	.28	226
						9,	.0012	.0198	6.89	.7900	.0000	.31	156
17,	50,000	56°	58°	-	-	16,	.0022	.0200	6.78	.4000	.0000	.24	29

Sewage applied 6 times a week.
Surface raked about 1 inch deep each week.
Effluent clear and practically colorless.

FILTER TANK NO. 6 — *Concluded.*

WEEK ENDING—	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE. Sewage.	TEMPERATURE. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Oct. 24,	60,000	51°	56°	54m.	-	Oct. 23,	.0340	.0256	6.14	.9900	.0030	.30	11,799
31,	60,000	47°	52°	-	-	30,	.0500	.0164	7.40	1.3700	.0014	.17	810
Nov. 7,	60,000	45°	48°	-	-	Nov. 6,	.0244	.0176	13.20	1.4000	.0006	.30	2,320
14,	60,000	45°	47°	12h.	-	13,	.0106	.0184	7.75	.9600	.0002	.20	2,028
21,	60,000	45°	47°	3h. 23m.	-	20,	.0144	.0236	6.05	.6100	.0004	.22	6,150
28,	60,000	43°	45°	-	1	27,	.0134	.0226	6.60	.3400	.0004	.23	1,100
Dec. 5,	50,000	40°	44°	17h. 30m.	½	Dec. 4,	.1500	.0640	7.58	.0400	.0012	.55	16,500
12,	40,000	45°	44°	23h.	1	11,	.0300	.0580	7.35	.6800	.0005	.74	4,000
19,	30,000	46°	42°	23h.	2½	18,	.1200	.0460	7.75	.0000	.0004	.55	82
26,	50,000	46°	43°	-	4	24,	.8300	.0860	10.33	.0100	.0000	.72	6,150

Sewage applied 6 times a week.
Surface raked about 1 inch deep each week; spaded 3 inches deep October 19 and December 2.
Effluent clear and practically colorless during October and November; slightly turbid in December.

Chemical and Biological Examinations of Effluent of Filter Tank No. 6, representing Different Parts of the Daily Flow.

DAY.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.										
Feb. 5,	9.30	80	0	.5600	.0380	4.65	.7000	.0016	.20	120
5,	12.04	6,060	50	.8400	.0540	4.54	.4000	.0020	.34	8,100
5,	12.28	9,240	100	.7200	.0500	4.47	.6100	.0032	.36	7,740
5,	1.31	9,600	260	.7600	.0660	4.52	.5700	.0036	.42	8,280
5,	1.50	8,160	301	.7000	.0500	4.52	.5900	.0050	.40	7,380
5,	2.59	3,780	401	.6600	.0440	4.54	.6100	.0036	.31	2,460
5,	5.26	1,240	478	.6000	.0400	4.54	.7000	.0032	.26	2,400

Feb. 5 — Sewage equivalent to 140,000 gallons per acre applied from 9.38 to 10.44.

DAY.	Hour.	Rate of Flow.	Amount Passed since Flooding.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Mar. 6,	8.50	240	0	.2800	.0300	3.42	1.2300	.0008	.10	200
6,	10.20	2,800	13	.4800	.0360	3.70	.6900	.0006	.22	2,280
6,	10.31	5,040	23	.5500	.0420	3.72	.6300	.0008	.22	9,720
6,	10.54	5,400	56	.5800	.0460	3.75	.6000	.0008	.23	9,720
6,	11.32	4,640	103	.5000	.0400	3.67	.7100	.0020	.20	4,080
6,	1.50	1,720	190	.3700	.0320	3.60	.9600	.0016	.12	2,760
6,	3.40	500	302	.2700	.0260	3.52	.9800	.0008	.11	360

March 6. — Sewage equivalent to 70,000 gallons per acre applied from 8.57 to 9.15.

Chemical and Biological Examinations of Effluent of Filter Tank No. 6, representing Different Parts of the Daily Flow — Concluded.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.										
Apr. 24,	2.10	180	0	.0124	.0132	4.87	3.5200	.0001	.07	96
24,	4.26	6,240	10	.0088	.0174	4.85	3.2200	.0001	.09	640
24,	4.33	7,080	20	.0112	.0198	4.82	2.4900	.0010	.09	500
24,	4.53	6,840	53	.0134	.0206	4.85	3.0600	.0000	.08	820
24,	5.25	4,800	100	.0056	.0206	4.87	2.9300	.0000	.09	1,400
24,	6.55	2,100	187	.0166	.0190	4.85	3.0600	.0000	.09	1,140
25,	9.40	230	299	.0078	.0178	4.87	2.9200	.0002	.06	68
April 24. — Sewage equivalent to 70,000 gallons per acre applied from 3.32 to 3.54.										
June 5,	2.30	140	0	.0026	.0162	8.92	2.4900	.0000	.16	21
5,	3.44	6,120	14	.0026	.0210	7.28	2.2900	.0002	.19	980
5,	3.52	6,600	24	.0022	.0234	7.10	1.9100	.0000	.19	1,848
5,	4.12	5,820	54	.0024	.0224	7.32	2.0500	.0000	.18	1,840
5,	4.50	3,960	104	.0022	.0240	7.88	2.2900	.0000	.16	720
5,	6.55	1,710	187	.0018	.0210	8.00	2.3700	.0000	.18	1,240
6,	12.25	180	304	.0014	.0138	7.63	2.2900	.0000	.18	-
June 5. — Sewage equivalent to 70,000 gallons per acre applied from 2.48 to 3.07.										
Oct. 2,	9.45	220	0	.0020	.0224	14.96	.3500	.0000	.26	720
2,	1.45	4,560	29	.0022	.0254	14.16	.3500	.0000	.29	1,140
2,	2.19	4,350	70	.0036	.0256	14.16	.3900	.0001	.32	800
2,	2.43	3,440	100	.0030	.0246	14.16	.3500	.0000	.29	1,018
2,	5.25	1,260	183	.0018	.0242	13.64	.3900	.0000	.29	820

Oct. 2. — Sewage equivalent to 70,000 gallons per acre applied from 11.14 to 11.29.

The following table contains a summary of twenty-nine microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 6.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Synedra,	3	4	100
Fungi. Molds,	3	2	50
ANIMALS.			
Rhizopoda. Amœba,	3	1	25
Infusoria.			
Monas,	11	25	250
Paramæcium,	6	12	100
Vermes.			
Anguillula,	6	4	50
Rotifer,	3	1	25
Miscellaneous. Starch,	3	4	100

Table showing the Amount of Nitrogen stored in the Sand at Different Depths, Calculated from Determinations of Free and Albuminoid Ammonia, and deducting the 1.33 Parts of Nitrogen contained in the Original Sand.

[Parts in 100,000 by weight of dry sand.]

Distance below Surface.	December, 1888.	June, 1889.	November, 1889.	July, 1891.	November, 1891.
0-¼ inch,	36.60	55.55	84.21	213.63	103.22
1 inch,	25.50	32.70	34.20	63.69	120.00
2 inches,	16.10	21.80	24.70	40.19	115.14
4 "	8.45	12.90	16.85	26.28	23.76
8 "	4.50	6.35	8.50	12.67	14.87
12 "	3.45	3.85	4.10	7.08	6.75
18 "	3.40	2.35	2.50	-	-
24 "	3.40	1.75	2.10	-	-
36 "	3.40	1.60	2.10	-	-
44 "	3.40	1.60	2.10	-	-

Table showing the Total Nitrogen applied to Tank 6; the Amount in the Effluent; and the Amount stored in the Sand, in Pounds.

	December, 1888.	June, 1889.	November, 1889.	July, 1891.	November, 1891.
Total nitrogen applied to date,	11.68	.66	23.79	55.05	65.56
Amount in effluent to date,	4.15	6.49	10.68	28.91	34.20
Amount stored in sand to date,	3.53	3.10	4.38	8.87	11.84
Amount lost to date,	4.00	6.07	8.73	18.61	19.52
Per cent. stored,	30	20	18	16	18
Per cent. lost,	34	39	37	34	30

Distribution of the Stored Nitrogen in the Sand.

Upper quarter inch,	.19	.29	.44	1.11	.54
Upper inch,	1.12	.90	1.54	3.99	2.84
Upper 3 inches,	1.78	1.76	2.52	5.84	7.32
Upper 6 inches,	2.20	2.43	3.44	7.38	9.98
Upper 12 inches,	[illegible]	2.99	4.23	8.71	11.60
Total, 44 inches,	[illegible]	[illegible]	4.38	8.87	11.84

FILTER TANK No. 7.

This large tank is filled with forty-four inches of No. 6 sand (the mechanical analyses of which were given on page 429), above which are ten inches of loam and six inches of soil. In June, 1889, a circular trench was cut three and one-half feet deep and two feet wide, the outer edge being eighteen inches from the outside of the filter; its area was one-third of that of the filter. Coarse gravel stones were placed in the trench to a depth of two feet, and in the middle was placed a six-inch drain pipe, thirty-eight feet long, with open joints once in two feet. The top of the drain pipe was level and even with the top of the gravel, eighteen inches below the surface. Above were placed loam and soil as before. Sewage was introduced through a vertical pipe from the surface, and on Oct. 21, 1889, this pipe was trapped, preventing the passage of air except through the loam and soil. The full history of the filter up to Oct. 31, 1889, and a summary of the results in 1890, were given in the report upon the Purification of Sewage and Water (pages 444 and 684).

The quantity of sewage applied, commencing October, 1889, was at the rate of 25,700 gallons per acre daily, with uniformly good results. Sept. 8, 1890, the quantity was increased to 34,300 gallons. This was followed by a temporary increase in free ammonia, but on December 11 the amount had again decreased to .0082 part per 100,000. After this it again rose steadily to 1.4000, April 24, accompanied by comparatively low nitrates. As there was no prospect of improvement, and the filter had evidently been overdosed, the quantity applied was reduced, April 6, to 17,100 gallons per acre daily. This was immediately followed by higher nitrates, although there was no reduction in the ammonia for six weeks; after that the ammonia steadily decreased, reaching .0018 August 18, and has remained equally low, with high nitrates, ever since.

The work of this filter for the entire time since sewage was first applied, January, 1888, is shown in the following table of average results for the most important periods : —

Average Results of Analyses of Sewage and Effluent of Filter Tank No. 7.

		Average Quantity. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January—September, 1888,	Sewage, .	25,000	1.3966	.8789	4.48	0	0	-	1,298,292
Surface application of sewage,	Effluent, .	25,600	.1628	.0162	4.41	.26	.0075	-	4,000
October, 1888—June, 1889,	Sewage, .	8,900	1.6511	.4029	4.81	0	0	-	714,802
Surface application of sewage,	Effluent, .	9,400	.0018	.0066	4.40	1.04	.0008	-	8
July—October, 1889, . . .	Sewage, .	15,200	2.0508	.7328	5.40	0	0	-	690,497
Sub-surface application of sewage.	Effluent, .	16,000	.0009	.0081	4.85	1.42	.0001	-	300
November, 1889—August, 1890,	Sewage, .	25,700	1.7500	.6500	5.54	0	0	3.02	850,000
Sub-surface application of sewage.	Effluent, .	26,200	.0024	.0111	5.49	1.15	.0001	.08	501
September, 1890—July, 1891,	Sewage, .	27,200	1.8400	.6500	6.18	0	0	3.23	798,000
34,300 gallons per acre daily, followed by 17,100 gallons — effect of overdosing.	Effluent, .	26,400	.5432	.0211	5.33	.95	.0059	.17	692
August—December, 1891, .	Sewage, .	17,200	2.7800	.8700	8.27	0	0	4.53	858,572
Improvement with reduced rate,	Effluent, .	-	.0018	.0088	8.34	2.14	.0002	.08	148

The weekly analyses are given in full in the following table : —

Filter Tank No. 7.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.											
Nov. 9, . .	25,714	48°	52°	Nov. 7, . .	.0002	.0100	5.27	1.7000	.0000	-	320
16, . .	25,714	47°	51°	14, . .	.0006	.0084	4.71	1.9000	.0000	-	162
23, . .	25,714	44°	49°	21, . .	.0000	.0094	4.50	1.7000	.0000	-	52
30, . .	25,714	44°	48°	28, . .	.0014	.0090	5.72	1.3600	.0002	-	25
Dec. 7, . .	25,714	39°	45°	Dec. 5, . .	.0010	.0108	4.32	1.5000	.0000	-	15
14, . .	25,714	39°	44°	12, . .	.0030	.0102	3.52	1.4000	.0012	-	81
21, . .	26,257	45°	42°	19, . .	.0020	.0102	6.55	1.1500	.0006	-	7,920
28, . .	25,714	45°	43°	26, . .	.0014	.0110	4.47	1.1000	.0000	-	-
1890.											
Jan. 4, . .	25,714	45°	43°	Jan. 2, . .	.0018	.0132	5.35	.9000	.0000	-	77
11, . .	27,143	45°	42°	9, . .	.0012	.0092	4.62	.6300	.0004	-	8
18, . .	25,714	45°	42°	16, . .	.0012	.0098	3.74	.8000	.0000	-	40
25, . .	25,714	45°	41°	23, . .	.0008	.0092	3.52	1.0000	.0000	-	-
Feb. 1, . .	25,714	44°	39°	28, . .	.0014	.0086	4.19	1.1000	.0002	-	26
				30, . .	.0018	.0106	3.95	1.2000	.0000	-	-
8, . .	25,714	44°	40°	Feb. 6, . .	.0052	.0118	4.62	1.0000	.0002	-	-
15, . .	27,143	44°	40°	13, . .	.0046	.0098	3.57	.8500	.0000	-	-
22, . .	25,714	45°	40°	20, . .	.0040	.0108	4.46	.8000	.0002	-	-
March 1, . .	25,714	45°	39°	27, . .	.0060	.0116	3.02	.7000	.0002	-	4
8, . .	25,714	45°	40°	Mar. 6, . .	.0068	.0108	4.02	.8000	.0000	.08	190
15, . .	25,714	45°	41°	13, . .	.0080	.0130	4.32	.7000	.0000	.09	12
22, . .	25,714	45°	41°	20, . .	.0036	.0080	2.82	.7000	.0000	.11	5
29, . .	25,714	45°	41°	27, . .	.0026	.0114	3.19	.5500	.0000	.07	13
Apr. 5, . .	25,714	45°	41°	Apr. 3, . .	.0032	.0154	3.51	.9500	.0000	.10	12
12, . .	25,714	45°	42°	10, . .	.0002	.0142	4.09	.8000	.0000	.16	212
19, . .	25,714	46°	45°	17, . .	.0014	.0124	6.74	1.0000	.0004	.09	10
26, . .	25,714	47°	46°	24, . .	.0042	.0146	5.39	1.0000	.0000	.07	27
May 3, . .	25,714	49°	48°	May 1, . .	.0018	.0126	4.90	1.3000	.0000	.09	142
10, . .	25,714	52°	51°	8, . .	.0022	.0104	4.00	1.2000	.0000	.08	121
17, . .	25,714	56°	53°	15, . .	.0016	.0142	4.27	1.8000	.0000	.07	372
24, . .	25,714	57°	56°	22, . .	.0006	.0106	5.98	1.7500	.0002	.07	29
31, . .	25,714	58°	57°	29, . .	.0064	.0124	5.40	1.4500	.0002	.11	227

Sewage applied 6 times a week.
Effluent clear and colorless.

FILTER TANK NO. 7 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
June 7, . .	25,714	61°	58°	June 5, . .	.0032	.0144	5.60	1.2500	.0000	.07	-
14, . .	25,714	61°	59°	12, . .	.0020	.0114	5.42	.8500	.0000	.09	19
21, . .	25,714	64°	62°	19, . .	.0004	.0092	4.85	1.1000	.0000	.06	47
28, . .	25,714	70°	63°	26, . .	.0028	.0092	5.70	1.1500	.0000	.09	38
July 5, . .	25,714	71°	66°	July 3, . .	.0016	.0090	8.23	1.1000	.0002	.08	466
12, . .	25,714	72°	68°	10, . .	.0022	.0140	7.76	1.2500	.0000	.06	2
19, . .	25,714	73°	69°	17, . .	.0012	.0112	7.82	1.5000	.0000	.08	143
26, . .	25,714	70°	69°	24, . .	.0016	.0120	7.95	1.5000	.0000	.08	5
Aug. 2, . .	25,714	72°	70°	31, . .	.0022	.0112	6.15	1.5000	.0000	.07	56
9, . .	25,714	76°	71°	Aug. 7, . .	.0018	.0106	7.87	1.4000	.0000	.08	33
16, . .	25,714	72°	72°	14, . .	.0014	.0106	8.90	1.5000	.0000	.07	122
23, . .	25,714	71°	71°	21, . .	.0008	.0094	12.30	1.1000	.0000	.07	337
30, . .	25,714	68°	70°	28, . .	.0010	.0108	14.00	1.2500	.0000	.08	-
Sept. 6, . .	25,714	66°	69°	Sept. 4, . .	.0040	.0120	7.00	1.0000	.0000	.07	-
13, . .	34,286	68°	68°	11, . .	.0024	.0094	6.30	.8900	.0000	.08	-
20, . .	34,286	66°	68°	18, . .	.0008	.0100	3.57	.4700	.0000	.09	626
27, . .	34,286	62°	66°	25, . .	.0028	.0106	5.87	.5000	.0000	.11	82
Oct. 4, . .	34,286	61°	64°	Oct. 2, . .	.0334	.0092	6.47	.6500	.0004	-	79
11, . .	34,286	59°	62°	9, . .	.0584	.0102	5.04	.6500	.0012	.13	213
18, . .	34,286	54°	60°	13, . .	.1280	.0140	4.90	.4500	.0014	.14	31
				16, . .	.0334	.0046	4.85	.7500	.0024	.12	84
25, . .	22,857	50°	56°	20, . .	.0552	.0104	2.40	.6000	.0012	.12	4,307
				23, . .	.1710	.0170	3.22	.7500	.0060	.11	939
Nov. 1, . .	34,286	48°	53°	30, . .	.1920	.0200	4.68	.9000	.0110	.14	145
8, . .	34,286	46°	50°	Nov. 6, . .	.1900	.0160	5.50	1.2200	.0120	.14	2
15, . .	34,286	45°	50°	13, . .	.0715	.0145	5.29	1.2300	.0120	.10	30
22, . .	34,286	43°	47°	20, . .	.0555	.0110	5.07	.9900	.0020	.10	36
29, . .	34,286	40°	46°	27, . .	.0440	.0092	6.46	.8400	.0030	.12	17
Dec. 6, . .	34,286	44°	43°	Dec. 4, . .	.0112	.0108	4.98	.8100	.0008	.11	1,680
13, . .	34,286	45°	42°	11, . .	.0082	.0084	4.34	.8900	.0009	.11	44
20, . .	34,286	46°	41°	18, . .	.0384	.0140	4.14	.6300	.0014	.16	6,240
27, . .	28,571	45°	41°	24, . .	.0184	.0106	3.82	.6700	.0007	.11	40

Sewage applied 6 times a week.
Experiments interrupted by high water in the river October 21 and 22.
Surface covered with a sparse growth of grass May to October.
Effluent clear and colorless.

FILTER TANK NO. 7 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Jan. 3, . .	34,286	46°	40°	Jan. 2, . .	.0610	.0150	5.03	.3500	.0012	.17	780
10, . .	34,286	45°	40°	9, . .	.1500	.0120	3.44	.4700	.0030	.17	1,580
17, . .	34,286	46°	39°	16, . .	.3200	.0200	5.70	.3000	.0035	.21	6,000
24, . .	34,286	46°	39°	23, . .	.4000	.0400	4.75	.1700	.0050	.24	3,640
31, . .	28,571	45°	38°	30, . .	.4600	.0280	4.08	.2000	.0060	.30	3,000
Feb. 7, . .	34,286	44°	38°	Feb. 6, . .	.5600	.0240	3.50	.1800	.0032	.23	1,140
14, . .	34,286	45°	38°	13, . .	.6000	.0240	6.00	.5000	.0050	.20	70
21, . .	34,286	44°	38°	20, . .	.5500	.0300	3.32	.2300	.0080	.18	152
28, . .	22,857	44°	38°	26, . .	.7200	.0400	3.62	.0400	.0100	.28	2,340
Mar. 7, . .	34,286	44°	37°	Mar. 6, . .	.8000	.0340	4.10	.1300	.0036	.29	280
14, . .	17,143	45°	37°	-	-	-	-	-	-	-	-
21, . .	28,571	44°	38°	20, . .	1.2600	.0200	2.92	.1800	.0040	.22	440
28, . .	0	-	-	-	-	-	-	-	-	-	-
Apr. 4, . .	34,286	46°	40°	Apr. 3, . .	.9500	.0200	3.34	.6500	.0100	.14	480
11, . .	34,286	45°	41°	10, . .	1.0500	.0200	3.62	.4300	.0036	.13	156
18, . .	5,714	47°	46°	-	-	-	-	-	-	-	-
25, . .	34,286	51°	48°	24, . .	1.4000	.0260	4.64	.5300	.0036	.16	420
May 2, . .	34,286	51°	50°	May 1, . .	1.1000	.0320	4.80	.8500	.0035	.20	138
9, . .	22,857	49°	50°	8, . .	1.2400	.0300	4.47	.5500	.0060	.21	118
16, . .	17,143	54°	53°	15, . .	1.3000	.0340	6.07	.7500	.0036	.21	92
23, . .	17,143	56°	55°	22, . .	1.4400	.0260	6.92	1.4600	.0040	.21	50
30, . .	17,143	57°	57°	29, . .	1.3200	.0420	8.08	1.8600	.0040	.21	0
June 6, . .	17,143	60°	59°	June 5, . .	1.3000	.0360	7.33	2.0000	.0060	.24	0
13, . .	17,143	63°	62°	12, . .	1.3000	.0320	6.18	1.3900	.0040	.21	9
20, . .	17,143	67°	61°	19, . .	.8500	.0320	5.80	2.1600	.0034	.15	10
27, . .	17,143	65°	64°	26, . .	.8000	.0240	7.60	2.4100	.0070	.16	0
July 4, . .	17,143	66°	65°	July 3, . .	.6800	.0280	9.52	1.5000	.0040	.18	0
11, . .	17,143	65°	65°	10, . .	.6400	.0200	9.24	2.7600	.0180	.16	9
18, . .	14,286	71°	69°	17, . .	.3800	.0240	8.77	2.9400	.0500	.15	-
25, . .	17,143	69°	69°	24, . .	.1500	.0140	8.10	3.6700	.0100	.16	738
Aug. 1, . .	17,143	67°	69°	31, . .	.0340	.0146	7.60	3.6100	.0120	.15	2,320
8, . .	17,143	68°	69°	Aug. 7, . .	.0102	.0136	9.11	3.7300	.0026	.04	100

Sewage applied 12 times a week to May 5 and afterwards 6 times a week.

Experiments interrupted by high water in the river January 25, 26, February 27, 28, March 12-16, 23-28 and April 13-17.

July 13, grass on surface cut.

Effluent clear and colorless excepting from February 27 to July 3, when it was slightly turbid.

FILTER TANK No. 7 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
June 7, . .	25,714	61°	58°	June 5, . .	.0032	.0144	5.60	1.2500	.0000	.07	-
14, . .	25,714	61°	59°	12, . .	.0020	.0114	5.42	.8500	.0000	.09	19
21, . .	25,714	64°	62°	19, . .	.0004	.0092	4.85	1.1000	.0000	.06	47
28, . .	25,714	70°	63°	26, . .	.0028	.0092	5.70	1.1500	.0000	.09	38
July 5, . .	25,714	71°	66°	July 3, . .	.0016	.0090	8.23	1.1000	.0002	.08	466
12, . .	25,714	72°	68°	10, . .	.0022	.0140	7.76	1.2500	.0000	.06	2
19, . .	25,714	73°	69°	17, . .	.0012	.0112	7.82	1.5000	.0000	.08	143
26, . .	25,714	70°	69°	24, . .	.0016	.0120	7.95	1.5000	.0000	.08	5
Aug. 2, . .	25,714	72°	70°	31, . .	.0022	.0112	6.15	1.5000	.0000	.07	56
9, . .	25,714	76°	71°	Aug. 7, . .	.0018	.0106	7.87	1.4000	.0000	.08	33
16, . .	25,714	72°	72°	14, . .	.0014	.0106	8.90	1.5000	.0000	.07	122
23, . .	25,714	71°	71°	21, . .	.0008	.0094	12.30	1.1000	.0000	.07	337
30, . .	25,714	68°	70°	28, . .	.0010	.0108	14.00	1.2500	.0000	.08	-
Sept. 6, . .	25,714	66°	69°	Sept. 4, . .	.0040	.0120	7.00	1.0000	.0000	.07	-
13, . .	34,286	68°	68°	11, . .	.0024	.0094	6.30	.8900	.0000	.08	-
20, . .	34,286	66°	68°	18, . .	.0008	.0100	3.57	.4700	.0000	.09	626
27, . .	34,286	62°	66°	25, . .	.0028	.0106	5.87	.5000	.0000	.11	82
Oct. 4, . .	34,286	61°	64°	Oct. 2, . .	.0334	.0092	6.47	.6500	.0004	-	79
11, . .	34,286	59°	62°	9, . .	.0584	.0102	5.04	.6500	.0012	.13	213
18, . .	34,286	54°	60°	13, . .	.1280	.0140	4.90	.4500	.0014	.14	31
				16, . .	.0334	.0046	4.85	.7500	.0024	.12	84
25, . .	22,857	50°	56°	20, . .	.0552	.0104	2.40	.6000	.0012	.12	4,307
				23, . .	.1710	.0170	3.22	.7500	.0060	.11	939
Nov. 1, . .	34,286	48°	53°	30, . .	.1920	.0200	4.68	.9000	.0110	.14	145
8, . .	34,286	46°	50°	Nov. 6, . .	.1900	.0160	5.50	1.2200	.0120	.14	2
15, . .	34,286	45°	50°	13, . .	.0715	.0145	5.29	1.2300	.0120	.10	30
22, . .	34,286	43°	47°	20, . .	.0555	.0110	5.07	.9900	.0020	.10	36
29, . .	34,286	40°	46°	27, . .	.0440	.0092	6.46	.8400	.0030	.12	17
Dec. 6, . .	34,286	44°	43°	Dec. 4, . .	.0112	.0108	4.98	.8100	.0008	.11	1,680
13, . .	34,286	45°	42°	11, . .	.0082	.0084	4.34	.8900	.0009	.11	44
20, . .	34,286	46°	41°	18, . .	.0384	.0140	4.14	.6300	.0014	.16	6,240
27, . .	28,571	45°	41°	24, . .	.0184	.0106	3.82	.6700	.0007	.11	40

Sewage applied 6 times a week.
Experiments interrupted by high water in the river October 21 and 22.
Surface covered with a sparse growth of grass May to October.
Effluent clear and colorless.

FILTER TANK NO. 7 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Jan. 3, . .	34,286	46°	40°	Jan. 2, . .	.0610	.0150	5.03	.3500	.0012	.17	780
10, . .	34,286	45°	40°	9, . .	.1500	.0120	8.44	.4700	.0030	.17	1,580
17, . .	34,286	46°	39°	16, . .	.3200	.0200	5.70	.3000	.0035	.21	6,000
24, . .	34,286	46°	39°	23, . .	.4000	.0400	4.75	.1700	.0050	.24	3,640
31, . .	28,571	45°	38°	30, . .	.4600	.0280	4.08	.2000	.0060	.30	3,000
Feb. 7, . .	34,286	44°	38°	Feb. 6, . .	.5600	.0240	3.50	.1800	.0032	.23	1,140
14, . .	34,286	45°	38°	13, . .	.6000	.0240	6.00	.5000	.0050	.20	70
21, . .	34,286	44°	38°	20, . .	.5500	.0300	3.32	.2300	.0060	.18	152
28, . .	22,857	44°	38°	26, . .	.7200	.0400	3.62	.0400	.0100	.28	2,340
Mar. 7, . .	34,286	44°	37°	Mar. 6, . .	.8000	.0340	4.10	.1300	.0036	.29	280
14, . .	17,143	45°	37°	-	-	-	-	-	-	-	-
21, . .	28,571	44°	38°	20, . .	1.2600	.0200	2.92	.1800	.0040	.22	440
28, . .	0	-	-	-	-	-	-	-	-	-	-
Apr. 4, . .	34,286	46°	40°	Apr. 3, . .	.9500	.0200	3.34	.6500	.0100	.14	480
11, . .	34,286	45°	41°	10, . .	1.0500	.0200	3.62	.4300	.0036	.13	156
18, . .	5,714	47°	46°	-	-	-	-	-	-	-	-
25, . .	34,286	51°	48°	24, . .	1.4000	.0260	4.64	.5800	.0036	.16	420
May 2, . .	34,286	51°	50°	May 1, . .	1.1000	.0320	4.80	.8500	.0035	.20	138
9, . .	22,857	49°	50°	8, . .	1.2400	.0300	4.47	.5500	.0060	.21	118
16, . .	17,143	54°	53°	15, . .	1.3000	.0340	6.07	.7500	.0036	.21	92
23, . .	17,143	56°	55°	22, . .	1.4400	.0260	6.92	1.4600	.0040	.21	50
30, . .	17,143	57°	57°	29, . .	1.3200	.0420	8.08	1.8600	.0040	.21	0
June 6, . .	17,143	60°	59°	June 5, . .	1.3000	.0360	7.33	2.0000	.0060	.24	0
13, . .	17,143	63°	62°	12, . .	1.3000	.0320	6.18	1.3900	.0040	.21	9
20, . .	17,143	67°	61°	19, . .	.8500	.0320	5.80	2.1600	.0034	.15	10
27, . .	17,143	65°	64°	26, . .	.8000	.0240	7.60	2.4100	.0070	.16	0
July 4, . .	17,143	66°	65°	July 3, . .	.6800	.0280	9.52	1.5000	.0040	.18	0
11, . .	17,143	65°	65°	10, . .	.6400	.0200	9.24	2.7600	.0180	.16	9
18, . .	14,286	71°	69°	17, . .	.3800	.0240	8.77	2.9400	.0500	.15	-
25, . .	17,143	69°	69°	24, . .	.1500	.0140	8.10	3.6700	.0100	.16	738
Aug. 1, . .	17,143	67°	69°	31, . .	.0340	.0146	7.60	3.6100	.0120	.15	2,320
8, . .	17,143	68°	69°	Aug. 7, . .	.0102	.0136	9.11	3.7300	.0026	.04	100

Sewage applied 12 times a week to May 5 and afterwards 6 times a week.

Experiments interrupted by high water in the river January 25, 26, February 27, 28, March 12-16, 23-28 and April 13-17.

July 13, grass on surface cut.

Effluent clear and colorless excepting from February 27 to July 3, when it was slightly turbid.

FILTER TANK NO. 7 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Aug. 15, . .	17,143	72°	70°	Aug. 14, . .	.0034	.0182	9.18	3.1700	.0002	.12	70
22, . .	17,143	71°	71°	21, . .	.0018	.0102	9.73	2.3300	.0000	.08	1,140
29, . .	17,143	72°	71°	28, . .	.0018	.0092	7.32	2.5500	.0000	.06	150
Sept. 5, . .	17,143	67°	69°	Sept. 4, . .	.0014	.0096	8.72	2.1100	.0000	.05	270
12, . .	17,143	64°	66°	11, . .	.0012	.0092	7.08	2.9900	.0000	.06	37
19, . .	17,143	66°	66°	18, . .	.0020	.0076	6.75	2.1100	.0000	.08	3
26, . .	17,143	67°	68°	25, . .	.0008	.0088	7.30	3.0200	.0001	.05	47
Oct. 3, . .	17,143	67°	68°	Oct. 2, . .	.0004	.0080	14.96	1.3200	.0000	.07	48
10, . .	17,143	60°	67°	9, . .	.0002	.0084	8.88	2.0700	.0002	.14	990
17, . .	17,143	52°	61°	16, . .	.0012	.0076	7.50	1.6700	.0000	.08	38
24, . .	17,143	50°	59°	23, . .	.0014	.0100	8.92	1.6700	.0002	.12	180
31, . .	17,143	46°	54°	30, . .	.0024	.0068	8.00	1.6300	.0000	.07	12
Nov. 7, . .	17,143	40°	51°	Nov. 6, . .	.0006	.0068	7.16	1.6300	.0002	.08	31
14, . .	17,143	48°	51°	13, . .	.0002	.0054	8.20	1.5900	.0001	.05	62
21, . .	17,143	47°	50°	20, . .	.0006	.0070	8.28	1.4500	.0000	.05	1
28, . .	17,143	47°	49°	27, . .	.0002	.0076	8.08	1.8500	.0000	.05	0
Dec. 5, . .	17,143	44°	47°	Dec. 4, . .	.0012	.0098	6.92	2.4300	.0000	.07	1
12, . .	17,143	45°	47°	11, . .	.0012	.0100	6.58	1.9700	.0002	.11	3
19, . .	17,143	44°	44°	18, . .	.0018	.0090	10.04	1.7000	.0000	.10	114
26, . .	17,143	47°	46°	24, . .	.0030	.0068	7.87	1.5300	.0002	.10	2

Sewage applied 6 times a week. Effluent clear and colorless.

Chemical and Biological Examinations of Effluent of Filter Tank No. 7, representing the Different Parts of the Daily Flow.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.										
Nov. 1,	9.55	220	0	.2030	.0090	5.42	1.0100	.0120	.10	8
1,	1.40	1,000	23	.1480	.0140	5.48	.7600	.0160	.09	41
1,	2.37	1,000	40	.1350	.0070	5.55	1.0700	.0120	.10	-
1,	3.33	880	54	.1370	.0080	5.44	1.0700	.0070	.08	20
1,	5.08	720	75	.1550	.0140	5.42	.8900	.0110	.09	199

Nov. 1. — Sewage equivalent to 40,000 gallons per acre applied from 10.11 to 10.20.

Chemical and Biological Examinations of Effluent of Filter Tank No. 7, representing the Different Parts of the Daily Flow — Concluded.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.										
Feb. 20,	8.03	430	0	.5800	.0300	3.42	.3400	.0080	.18	160
20,	9.30	400	10	.5800	.0300	3.42	.3400	.0080	.18	27
20,	11.05	410	20	.6200	.0300	3.40	.2900	.0080	.18	175
20,	1.55	480	40	.5500	.0300	3.32	.3300	.0080	.18	152
20,	4.43	480	60	.5500	.0220	3.20	.3300	.0060	.21	116
20,	6.50	660	80	.5500	.0300	3.40	.2700	.0080	.23	700

Feb. 20. — Doses of sewage, each equivalent to 20,000 gallons per acre, applied from 8.24 to 8.29 and from 2.59 to 3.07.

The following table contains a summary of twenty-four microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 7.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Stephanodiscus,	4	1	25
Synedra,	12	3	25
Tabellaria,	4	2	50
Algæ.			
Chlorococcus,	4	5	125
Ulothrix,	4	2	50
ANIMALS.			
Infusoria.			
Monas,	4	2	50
Paramæcium,	8	600	14,800

FILTER TANK No. 9 A.

The hard pan of clay, sand and gravel mentioned in the report upon the Purification of Sewage and Water (page 3), in more than two years' work, proved itself to be totally unfit for the work of sewage purification; it was practically water-tight. In October, 1890, it was removed, and in its place was put, above the usual under-draining materials, five feet of sand intermediate in size between No. 1 and No. 2, nearly like that used for filters 17 A and 19, and having the mechanical analysis given on page 429.

In starting all previous filters the quantity of sewage at first applied had been comparatively small, and after an established condition of purification was attained, the doses were increased. We felt confident from our experiences with other filters that this tank could, in the same way, be made to purify as much as 100,000 gallons per acre daily. It being established from analogy in advance approximately what the capacity of this filter would be, it was decided to apply at once the full quantity to see if the gradual increase was either necessary or desirable. Sewage was accordingly applied November 18, 1890, at the rate of 103,000 gallons per acre daily, after first applying city water for two weeks. The surface was given a weekly raking, and during the winter snow was removed, but no covering was used.

As a result of this treatment the free ammonia of the effluent rapidly increased to nearly that of the sewage and remained high until after nitrification had commenced in April. There was, however, good purification, as judged by the reduction in albuminoid ammonia and oxygen consumed. We have here, as in the other filters when exposed to winter weather, an oxidation of organic matter to ammonia and carbonic acid, the process of nitrification being imperfect or even completely checked. The first and most important step in purification was taken, but the conditions were unfavorable to the last step, — the oxidation of ammonia to nitrates.

A slight but definite nitrification was observed with this filter almost from the beginning, but there was no considerable amount

until the temperature commenced to increase. The temperature and nitrates, by months, were as follows: —

[Parts per 100,000.]

	Temperature.	Nitrates.
1890.		
December,	37°	.08
1891.		
January,	36°	.035
February,	36°	.08
March,	38°	.23
April,	44°	1.22
May,	56°	2.26

From the beginning of May nitrification was complete, and the results were most satisfactory in every way until August 28. At that time the organic matter which had been slowly accumulating on the surface suddenly formed a scum and excluded the air. On August 30 the surface was spaded up four inches deep, breaking the scum and admitting air. The nitrates immediately increased and in a short time the filter had quite recovered itself, and continued doing good work until the scum again formed, on October 23, increasing the ammonia and decreasing the nitrates.

On November 5 ridges and trenches, like those on Filter No. 2, were made on the surface, but no marked improvement followed. It was subsequently found that there was clogging below the surface in a fine stratified layer similar to that described under Filter No. 3.

This material is capable of taking for a limited time the large dose of 103,000 gallons per acre daily, but it does not seem probable that it can permanently purify so large a quantity without change of surface sand.

The year's work can be divided into periods, — first, before complete nitrification, second, with complete nitrification, and a third, in which the first effects of overdosing show themselves, although as yet good purification is maintained. The quantity applied was uniform for the entire year, except that the experiments were stopped for a short time in the spring by high water in the river, and that the amount which could be applied during November and December was limited by the clogging of the surface. The average results for these periods are as follows: —

Average Analyses of Sewage and Effluent of Filter Tank No. 9 A, by Periods.

		Quantity Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
December 1890—April, 1891,	Sewage,	88,600	1.4300	.5600	4.64	0	0	2.80	514,000
Before nitrification,	Effluent,	-	1.2447	.0321	4.86	.33	.0038	.19	1,334
May—July, 1891,	Sewage,	103,000	2.3900	.7709	9.77	0	0	3.61	780,000
Nitrification,	Effluent,	-	.0072	.0144	11.14	2.36	.0221	.17	8
August—December, 1891,	Sewage,	64,400	2.7800	.8700	8.27	0	0	4.53	858,572
First effect of overdosing,	Effluent,	-	.2095	.0241	9.24	1.45	.0061	.28	1,213

The results of the weekly analyses are given in full in the following table:—

FILTER TANK NO. 9 A.

Week Ending—	Quantity Applied — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.				Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.													
Nov. 1,	-	-	-	-	-	Nov. 1,	.0060	.0348	.37	.0120	.0000	.10	30
8,	102,857	51°	48°	-	-	8,	.0102	.0032	.20	.0150	.0000	.01	131
15,	102,857	49°	48°	1h. 2m.	-	12,	.0060	.0066	.17	.0190	.0000	.04	26
22,	102,857	43°	46°	-	-	19,	.0082	.0036	.18	.0200	.0000	.04	10
						22,	.0138	.0330	5.27	.0350	.0004	.19	1,740
29,	102,857	39°	43°	2h.	4	26,	.4200	.0820	5.70	.0800	.0045	.20	9,360
						29,	.9500	.0410	4.60	.1090	.0040	.23	14,220
Dec. 6,	102,857	44°	39°	-	5¾	Dec. 3,	1.0500	.0440	5.42	.1300	.0050	.26	1,200
						6,	1.2000	.0340	4.40	.1400	.0080	.25	12,500
13,	102,857	45°	37°	12h.	6	10,	.7500	.0340	6.94	.0800	.0100	.22	3,780
						13,	1.3600	.0360	5.05	.0800	.0012	.21	8,080
20,	102,857	45°	37°	-	8	17,	1.4400	.0300	4.79	.0250	.0020	.27	4,200
27,	100,000	45°	36°	-	4	24,	1.2000	.0360	4.87	.0300	.0012	.21	2,640
1891.													
Jan. 3,	90,864	45°	36°	-	6	Jan. 2,	1.5600	.0360	4.64	.0500	.0005	.18	900
10,	102,857	45°	35°	-	5¾	9,	1.3000	.0340	4.98	.0240	.0004	.19	675
17,	102,857	46°	35°	-	4¾	16,	1.2000	.0220	4.22	.0300	.0010	.13	600

City water applied 6 times a week, November 3-17; afterwards sewage applied 6 times a week. Surface raked (or picked) about 1 inch deep each week. Snow and ice removed from surface December 11, 12, 18, 22, 27; January 1, 6.

Effluent clear and colorless.

FILTER TANK NO. 9 A — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Jan. 24,	102,857	44°	35°	4h. 34m.	3	Jan. 23,	1.2000	.0260	4.28	.0300	.0008	.20	1,020
31,	85,714	44°	36°	3h. 27m.	1¼	30,	1.4000	.0360	4.30	.0400	.0006	.21	3,600
Feb. 7,	102,857	44°	36°	-	2¾	Feb. 6,	1.2000	.0220	3.74	.0700	.0014	.19	590
14,	102,857	44°	35°	-	2½	13,	1.4000	.0280	4.14	.0800	.0007	.17	102
21,	102,857	44°	36°	-	2¼	20,	1.3000	.0240	3.74	.0900	.0010	.19	188
28,	68,571	44°	37°	-	1	26,	1.2600	.0320	3.55	.0700	.0009	.20	420
Mar. 7,	102,857	44°	37°	-	2¼	Mar. 6,	1.3000	.0380	3.42	.1400	.0010	.14	132
14,	51,429	44°	38°	4h.	½	-	-	-	-	-	-	-	-
21,	85,714	44°	39°	-	1½	20,	1.2600	.0200	3.27	.2400	.0030	.19	96
28,	0	-	-	-	0	-	-	-	-	-	-	-	-
Apr. 4,	102,857	45°	41°	2h. 9m.	0	31,	1.8000	.0200	3.82	.4500	.0070	.11	1
						Apr. 3,	1.5200	.0700	5.32	.3300	.0050	.14	36
11,	102,857	44°	42°	-	-	10,	1.1000	.0280	4.90	.4700	.0018	.13	156
18,	0	-	-	-	-	-	-	-	-	-	-	-	-
25,	68,571	52°	51°	2h. 16m.	-	24,	.4000	.0180	4.03	2.8600	.0200	.24	80
May 2,	102,857	50°	52°	-	-	May 1,	.1200	.0240	7.10	2.2400	.1700	.32	84
9,	102,857	50°	52°	-	-	5,	.0206	.0110	5.30	2.3000	.1000	.21	26
						8,	.0060	.0102	5.40	2.1000	.0500	.19	28
16,	102,857	56°	55°	-	-	12,	.0026	.0118	6.50	2.0400	.0050	.10	30
						15,	.0026	.0138	8.10	2.1300	.0110	.12	0
23,	102,857	55°	58°	-	-	19,	.0018	.0116	5.30	1.9900	.0006	.13	0
						22,	.0012	.0128	6.55	2.4900	.0400	.16	17
30,	102,857	60°	61°	-	-	26,	.0016	.0130	6.02	2.1600	.0340	.16	8
						29,	.0016	.0170	10.10	2.7700	.0320	.20	5
June 6,	102,857	63°	63°	-	-	June 5,	.0038	.0174	11.88	2.4600	.0300	.23	1
13,	102,857	64°	66°	-	-	12,	.0024	.0160	16.92	2.5000	.0350	.18	1
20,	102,857	69°	70°	-	-	19,	.0030	.0198	15.15	2.7600	.0024	.19	0
27,	102,857	67°	68°	3h. 23m.	-	26,	.0026	.0108	8.14	2.1100	.0000	.14	0
July 4,	102,857	67°	69°	2h. 57m.	-	July 3,	.0010	.0140	10.58	2.3300	.0000	.17	0
11,	102,857	67°	67°	-	-	10,	.0010	.0134	10.06	1.8900	.0008	.12	0

Sewage applied six times a week. Surface raked (or picked) about one inch deep each week.
Snow and ice removed from surface January 19, 20, 26; February 9, 10, 27; March 2, 4, 5.
Experiments interrupted by high water in the river January 25, 26; February 27, 28; March 12-16, 23-29; April 14-17.
Effluent clear and colorless.

Average Analyses of Sewage and Effluent of Filter Tank No. 9 A, by Periods.

		Quantity Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
December 1890—April, 1891,	Sewage,	88,600	1.4300	.5600	4.64	0	0	2.80	514,000
Before nitrification,	Effluent,	-	1.2447	.0321	4.86	.33	.0038	.19	1,334
May—July, 1891,	Sewage,	103,000	2.3900	.7700	9.77	0	0	3.61	780,000
Nitrification,	Effluent,	-	.0072	.0144	11.14	2.36	.0221	.17	8
August—December, 1891,	Sewage,	64,400	2.7800	.8700	8.27	0	0	4.53	858,572
First effect of overdosing,	Effluent,	-	.2095	.0241	9.24	1.45	.0061	.28	1,213

The results of the weekly analyses are given in full in the following table: —

FILTER TANK NO. 9 A.

Week Ending—	Quantity Applied — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.				Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.													
Nov. 1,	-	-	-	-	-	Nov. 1,	.0060	.0348	.37	.0120	.0000	.10	30
8,	102,857	51°	48°	-	-	8,	.0102	.0032	.20	.0150	.0000	.01	131
15,	102,857	49°	48°	1h. 2m.	-	12,	.0050	.0066	.17	.0190	.0000	.04	26
22,	102,857	43°	46°	-	-	19,	.0082	.0036	.18	.0200	.0000	.04	10
						22,	.0138	.0330	5.27	.0350	.0004	.19	1,740
29,	102,857	39°	43°	2h.	4	26,	.4200	.0820	5.70	.0800	.0045	.20	9,360
						29,	.9500	.0410	4.60	.1000	.0040	.23	14,220
Dec. 6,	102,857	44°	39°	-	5¾	Dec. 3,	1.0500	.0440	5.42	.1300	.0050	.26	1,200
						6,	1.2000	.0340	4.40	.1400	.0080	.25	12,500
13,	102,857	45°	37°	12h.	6	10,	.7500	.0340	6.94	.0800	.0100	.22	3,780
						13,	1.3600	.0360	5.05	.0800	.0012	.21	8,080
20,	102,857	45°	37°	-	8	17,	1.4400	.0300	4.79	.0250	.0020	.27	4,200
27,	100,000	45°	36°	-	4	24,	1.2000	.0360	4.87	.0300	.0012	.21	2,640
1891.													
Jan. 3,	90,864	45°	36°	-	6	Jan. 2,	1.5600	.0360	4.64	.0500	.0005	.18	900
10,	102,857	45°	35°	-	5¾	9,	1.3000	.0340	4.98	.0240	.0004	.19	675
17,	102,857	46°	35°	-	4¾	16,	1.2000	.0220	4.22	.0300	.0010	.13	600

City water applied 6 times a week, November 3-17; afterwards sewage applied 6 times a week Surface raked (or picked) about 1 inch deep each week. Snow and ice removed from surface December 11, 12, 18, 22, 27; January 1, 6.

Effluent clear and colorless.

FILTER TANK No. 9 A — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
Jan. 24,	102,857	44°	35°	4h. 34m.	3	Jan. 23,	1.2000	.0260	4.28	.0300	.0008	.20	1,020
31,	85,714	44°	36°	3h. 27m.	1½	30,	1.4000	.0360	4.30	.0400	.0006	.21	3,600
Feb. 7,	102,857	44°	36°	-	2¾	Feb. 6,	1.2000	.0220	3.74	.0700	.0014	.19	500
14,	102,857	44°	35°	-	2¼	13,	1.4000	.0280	4.14	.0800	.0007	.17	102
21,	102,857	44°	36°	-	2¼	20,	1.3000	.0240	3.74	.0900	.0010	.19	188
28,	68,571	44°	37°	-	1	26,	1.2600	.0320	3.55	.0700	.0009	.20	420
Mar. 7,	102,857	44°	37°	-	2¼	Mar. 6,	1.3000	.0380	3.42	.1400	.0010	.14	132
14,	51,429	44°	38°	4h.	¼	-	-	-	-	-	-	-	-
21,	85,714	44°	39°	-	1½	20,	1.2600	.0200	3.27	.2400	.0030	.19	96
28,	0	-	-	-	0	-	-	-	-	-	-	-	-
Apr. 4,	102,857	45°	41°	2h. 9m.	0	31,	1.8000	.0200	3.82	.4500	.0070	.11	1
						Apr. 3,	1.5200	.0700	5.32	.3300	.0050	.14	36
11,	102,857	44°	42°	-	-	10,	1.1000	.0280	4.90	.4700	.0018	.13	156
18,	0	-	-	-	-	-	-	-	-	-	-	-	-
25,	68,571	52°	51°	2h. 16m.	-	24,	.4000	.0180	4.03	2.8600	.0200	.24	80
May 2,	102,857	50°	52°	-	-	May 1,	.1200	.0240	7.10	2.2400	.1700	.32	84
9,	102,857	50°	52°	-	-	5,	.0206	.0110	5.30	2.3000	.1000	.21	26
						8,	.0060	.0102	5.40	2.1000	.0500	.19	28
16,	102,857	56°	55°	-	-	12,	.0026	.0118	6.50	2.0400	.0050	.10	30
						15,	.0026	.0138	8.10	2.1300	.0110	.12	0
23,	102,857	55°	58°	-	-	19,	.0018	.0116	5.30	1.9900	.0006	.13	0
						22,	.0012	.0128	6.55	2.4900	.0400	.16	17
30,	102,857	60°	61°	-	-	26,	.0016	.0130	6.02	2.1600	.0340	.16	8
						29,	.0016	.0170	10.10	2.7700	.0320	.20	5
June 6,	102,857	63°	63°	-	-	June 5,	.0038	.0174	11.88	2.4600	.0300	.23	1
13,	102,857	64°	66°	-	-	12,	.0024	.0160	16.92	2.5000	.0350	.18	1
20,	102,857	69°	70°	-	-	19,	.0030	.0198	15.15	2.7600	.0024	.19	0
27,	102,857	67°	68°	3h. 23m.	-	26,	.0026	.0108	8.14	2.1100	.0000	.14	0
July 4,	102,857	67°	69°	2h. 57m.	-	July 3,	.0010	.0140	10.58	2.3300	.0000	.17	0
11,	102,857	67°	67°	-	-	10,	.0010	.0134	10.06	1.8900	.0008	.12	0

Sewage applied six times a week. Surface raked (or picked) about one inch deep each week.
Snow and ice removed from surface January 19, 20, 26; February 9, 10, 27; March 2, 4, 5.
Experiments interrupted by high water in the river January 25, 26; February 27, 28; March 12-16, 23-29; April 14-17.
Effluent clear and colorless.

FILTER TANK NO. 9 A — *Concluded.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.													
July 18,	102,857	72°	72°	-	-	July 17,	.0024	.0152	12.30	3.0800	.0000	.19	-
25,	102,857	73°	74°	1h. 30m.	-	24,	.0002	.0114	19.40	2.6400	.0000	.11	4
Aug. 1,	102,857	70°	73°	-	-	31,	.0004	.0130	16.08	1.9800	.0000	.15	0
8,	102,857	70°	72°	-	-	Aug. 7,	.0020	.0132	15.75	2.4200	.0000	.05	0
15,	102,857	74°	74°	-	-	14,	.0014	.0130	14.05	3.2100	.0000	.15	1
22,	102,857	73°	75°	-	-	21,	.0002	.0124	17.93	2.5500	.0001	.15	0
29,	102,857	73°	75°	-	-	28,	.1960	.0196	13.92	.9000	.0012	.24	14
Sept. 5,	102,857	68°	71°	5h. 39m.	-	Sept. 4,	.7500	.0400	9.46	1.3500	.0130	.36	9,660
12,	102,857	66°	69°	-	-	11,	.1500	.0240	6.60	1.7000	.0260	.22	342
19,	102,857	67°	69°	-	-	18,	.0240	.0160	7.10	2.4500	.0024	.15	90
26,	102,857	70°	70°	2h. 36m.	-	25,	.0046	.0176	8.80	2.6400	.0010	.19	35
Oct. 3,	97,143	69°	71°	-	-	Oct. 2,	.0006	.0132	8.36	2.3300	.0000	.14	2
10,	102,857	63°	67°	-	-	9,	.0008	.0128	8.88	2.4700	.0002	.17	5
17,	84,287	56°	60°	16h. 30m.	-	16,	.0036	.0120	8.56	1.2300	.0000	.16	18
24,	47,143	53°	57°	36h,	-	23,	.1300	.0120	7.48	1.3000	.0080	.13	25
31,	34,287	47°	52°	36h.	-	30,	.1560	.0280	8.00	1.2400	.0120	.16	10
Nov. 7,	34,287	43°	49°	-	-	Nov. 6,	.3300	.0200	13.55	.8000	.0030	.20	24
14,	34,287	45°	49°	-	-	13,	.2100	.0200	9.25	1.5000	.0150	.24	160
21,	22,857	44°	48°	-	-	17,	.1800	.0300	7.78	.8100	.0110	.26	874
	•					20,	.0372	.0224	7.02	.7200	.0008	.30	324
28,	0	-	47°	-	-	24,	.0900	.0220	6.49	.4500	.0044	.32	0
						27,	.0400	.0240	6.33	.8000	.0036	.29	2
Dec. 5,	31,429	41°	45°	-	2½	Dec. 1,	.0480	.0260	6.20	1.2000	.0060	.33	104
						4,	.3800	.0400	6.50	.1200	.0150	.52	2,000
12,	25,714	45°	45°	-	¾	11,	.7800	.0540	5.83	.2000	.0160	.93	12
19,	25,714	45°	44°	-	1	18,	.6300	.0300	5.82	.5100	.0060	.51	9,585
26,	17,143	44°	43°	-	0	24,	.9600	.0[illegible]	6.32	.0100	.0034	.61	4,725

Sewage applied 6 times a week. Surface raked about 1 inch deep each week.
Surface spaded up 3 to 4 inches deep August 31 and October 19.
November 5, surface made into ridges and trenches.
November 9, ½ inch sand removed from surface of trenches and put upon ridges.
Effluent clear and colorless until December 1; afterwards very slightly turbid.

In the following table of analyses, representing the different parts of the daily flow, the first section shows the results of frequent examinations of the effluent when the filter was first drained after

being saturated with city water; the second section shows the results immediately following the first application of sewage to this filter, and the remainder of the table shows the results when the filter was in regular use:—

Chemical and Biological Examinations of Effluent of Filter Tank No. 9 A, representing the Different Parts of the Daily Flow.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.										
Oct. 31,	9.16	75,000	215	.0002	.0052	.50	.0160	.0000	.08	49,383
31,	9.55	57,000	824	.0002	.0056	.20	.0160	.0000	.08	34,200
31,	10.22	50,000	1,240	.0008	.0048	.22	.0160	.0000	.09	33,840
31,	10.56	42,000	1,647	.0020	.0132	.29	.0170	.0000	.11	2,419
31,	11.45	24,000	2,128	.0074	.0330	.34	.0170	.0000	.15	576
31,	1.35	4,000	2,324	.0068	.0416	.34	.0170	.0000	.19	86
Nov. 1,	7.50	540	2,763	.0060	.0348	.37	.0120	.0000	.10	30

First water through: outlet opened at 9.11.

Nov. 18,	10.43†	460	0	.0032	.0040	.18	.0200	.0000	.03	36
19,	2.32*	2,240	48	.0032	.0036	.18	.0200	.0000	.04	10
19,	6.50*	2,800	287	.0052	.0040	.27	.0210	.0002	.05	8
19,	9.49*	1,740	382	.0058	.0074	.46	.0140	.0008	.05	8
20,	5.06†	810	513	.0064	.0082	.81	.0300	.0008	.07	10
20,	11.15†	430	2	.0072	.0128	1.06	.0390	.0008	.09	88
20,	2.35*	2,820	50	.0096	.0172	1.52	.0360	.0018	.11	400
20,	4.20*	3,840	152	.0100	.0178	1.90	.0390	.0026	.11	48
20,	8.44*	2,220	352	.0156	.0170	2.45	.0310	.0020	.11	56
21,	8.38†	600	550	.0110	.0220	3.30	.0380	.0016	.15	1,480
21,	5.16*	3,600	212	.0142	.0270	3.96	.0350	.0020	.15	1,980
22,	5.08†	740	522	.0134	.0272	5.15	.0300	.0004	.20	19,800
22,	3.35*	3,600	122	.0138	.0330	5.27	.0350	.0004	.19	1,740
24,	4.36*	2,520	69	.0550	.0368	6.14	.0140	.0002	.18	29,520

Doses of sewage, each equivalent to 120,000 gallons per acre daily, applied November 18, 10.48 to 11.41; November 19, 11.17 to 11.53; November 20, 10.57 to 11.48; November 21, 11.00 to 11.50; November 22, 11.32 to 11.54; November 24, 10.50 to 11.39. This was the first sewage applied, and the chlorine in the effluent shows when it commenced to come through.

Dec. 13,	8.03	760	0	1.3600	.0500	5.17	.0900	.0014	.21	3,040
13,	10.83	2,200	56	1.3000	.0560	5.10	.0900	.0014	.21	2,200
13,	12.13	1,080	106	1.3600	.0420	5.07	.0800	.0018	.20	5,760
13,	5.13	1,240	163	1.3600	.0360	5.05	.0800	.0012	.21	8,080
13,	8.44	2,860	241	1.5000	.0340	5.10	.0600	.0012	.23	9,000
14,	7.02	880	500	1.4400	.0420	5.07	.0600	.0010	.21	4,680

Sewage equivalent to 120,000 gallons per acre applied from 8.34 to 2.26.

* P.M. † A.M.

Chemical and Biological Examinations of Effluent of Filter Tank No. 9 A, representing the Different Parts of the Daily Flow — Concluded.

Day.	Hour.	Rate of Flow. — Cubic Centimeters per Minute.	Amount Passed since Flooding. — Gallons.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.										
May 1,	10.23	780	0	.0900	.0240	7.52	2.3400	.1400	.28	38
1,	11.50	9,600	45	.1200	.0240	7.10	2.2400	.1700	.32	84
1,	8.40*	2,460	238	.0515	.0145	6.60	2.3500	.1200	.25	36
2,	5.40†	1,140	468	.0485	.0110	6.54	2.4500	.0600	.22	16
Sewage equivalent to 120,000 gallons per acre applied from 10.49 to 11.45.										
June 12,	10.35	680	0	.0028	.0176	17.40	2.7600	.0040	.17	2
12,	12.05	5,160	49	.0024	.0160	16.92	2.5000	.0350	.18	1
12,	4.22	2,440	100	.0018	.0182	14.32	2.4500	.0080	.16	18
12,	6.45*	2,960	146	.0018	.0184	13.88	2.8300	.0250	.21	0
13,	5.32†	840	510	.0014	.0154	12.30	2.9400	.0040	.15	0
Sewage equivalent to 120,000 gallons per acre applied from 10.49 to 11.52.										
Oct. 9,	1.39	820	0	.0020	.0126	8.84	2.4200	.0000	.15	1
9,	4.19	1,000	50	.0008	.0128	8.88	2.4700	.0002	.17	44
9,	6.50*	800	84	.0012	.0136	8.77	2.2900	.0001	.17	5
9,	8.42*	1,060	139	.0014	.0122	8.80	2.3800	.0001	.17	2
10,	5.37†	1,500	416	.0012	.0134	8.00	1.6300	.0001	.17	14
10,	10.09†	1,140	500	.0016	.0130	7.72	1.7200	.0001	.16	6

Sewage equivalent to 120,000 gallons per acre applied from 1.40 to 3.05.

* P.M. † A.M.

The following table contains a summary of twenty-six microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 9 A.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Melosira,	4	4	100
Synedra,	4	6	150
Algæ.			
Chlorococcus,	4	8	200
Ulothrix,	4	1	25
Fungi. Molds,	12	35	800
ANIMALS.			
Infusoria.			
Monas,	8	8	100
Paramæcium,	4	1	25
Vermes.			
Anguillula,	8	2	25
Rotatorian ova,	4	8	200
Miscellaneous. Starch,	8	2	25

Table showing the Amount of Nitrogen stored in the Sand at Different Depths, calculated from Determinations of Free and Albuminoid Ammonia, and deducting the 1.33 Parts of Nitrogen contained in the Original Sand.

[Parts in 100,000 by weight of dry sand.]

Distance Below Surface.	March, 1891.	June, 1891.	November, 1891.
0-¼ inch,	99.02	159.00	148.32
1 inch,	55.08	30.70	52.38
2 inches,	23.54	22.28	70.50
4 "	16.67	14.23	45.57
8 "	11.05	7.92	11.07
12 "	5.08	3.88	7.00
18 "	3.17	2.09	3.88
24 "	2.17	1.37	1.59
36 "	1.39	1.56	1.62
48 "	1.39	.48	0
60 "	.97	0	0

Table showing the Total Nitrogen applied to Filter Tank No. 9 A, the Amount in the Effluent, and the Amount stored in the Sand, in Pounds.

	March, 1891.	June, 1891.	November, 1891.
Total nitrogen applied to date,	11.12	21.11	38.55
Amount in effluent to date,	5.65	13.55	23.63
Amount stored in sand to date,	5.03	4.82	8.39
Amount lost to date,	.44	2.74	6.53
Per cent. stored,	45	23	22
Per cent. lost,	4	13	17

Distribution of the Stored Nitrogen in the Sand.

	March, 1891.	June, 1891.	November, 1891.
Upper quarter inch,	.44	.70	.66
Upper inch,	1.20	1.23	1.91
Upper 3 inches,	2.04	2.48	3.86
Upper 6 inches,	2.86	3.68	5.80
Upper foot,	3.74	4.43	6.89
Total, five feet,	5.03	4.82	8.39

FILTER TANKS Nos. 11 AND 12.

These small tanks, twenty inches in diameter, No. 11 filled with 44 inches of No. 6 sand and No. 12 filled with 60 inches of No. 1 sand, were described in the report upon the Purification of Sewage and Water, 1890. In the time since then they have been used for special experiments in regard to nitrification.

Nitrification in Presence of Salt.

In 1890 experiments were made on Filter 11 to determine whether the presence of large amounts of chlorine caused a loss of nitrogen during nitrification. For this purpose city water was applied to the filter, to which was added definite amounts of ammonia and salt. The first result indicated a loss of nitrogen, but it was subsequently found that the apparent loss was due to imperfection in the method of analysis followed; that in presence of chlorine the phenolsulphonic acid process gave low results, and with the very large amount of chlorine present the figures obtained were quite misleading. By the aid of another nitrate process, which was adopted in June, it was found that there was no considerable amount of nitrogen lost during nitrification in presence of salt.

Nitrification in Presence of Sugar.

In 1891 sugar with ammonia was added to the dose of water, and the results, which had been earlier obtained upon Filter 12, were confirmed. In the presence of sugar there was a very large loss of nitrogen which could not possibly be attributed to any analytical imperfections. The subsequent application of the ammonia without the sugar, and later, of city water by itself, showed that the nitrogen of the ammonia unaccounted for was not stored in the filter in such a way as to be removed after the sugar was no longer applied,

but was probably given off as free nitrogen. Filter 12 had been previously used for experiment with sugar, as described in the report upon the Purification of Sewage and Water (pages 134 and 730). In March, 1890, the applied dose was a solution containing 20 parts per 100,000 of sugar and 4 parts of nitrogen as ammonia, but on April 6 the quantity of nitrogen was reduced to 2 parts. On July 4 the amount of sugar was increased to 40 parts, and on December 8 to 100 parts, which was continued until June 16, 1891. The general result of these experiments was to show a loss of nitrogen, especially after increasing the dose of sugar, but as the doses were continued the nitrogen in the effluent generally increased, showing that the filter was acquiring the power of nitrifying the ammonia in presence of the sugar more readily than at first. In April the nitrogen in the effluent was higher than in the applied dose, due to exceptionally high nitrates in a single sample after the filter had been out of use for nine days owing to high water in the river, and during the following months the nitrates remained very high, indicating that the filter had at last acquired the power of complete nitrification in presence of sugar.

Application of Soap.

Commencing Aug. 11, 1890, a solution of soap containing 90 parts per 100,000 of soap, equal to 63 parts fatty acids, was applied to Filter 12. Its effect was to immediately and completely stop nitrification, but notwithstanding this a good purification was obtained. On September 3 the quantity of soap was increased to 440 parts in 100,000, which was continued throughout the month, at the end of which the filter had become clogged and incapable of taking more soap. The effluent also contained much organic matter. The filter was allowed to rest until October 12, when a solution of 90 parts per 100,000 of soap was applied, but October 14 the filter was again so clogged that the dose would not pass. City water was then passed through the filter, but when the solution of soap was again applied, after more than two months, December 27, it would not pass. The filter evidently did not recover during the period when soap was not used. After again applying city water by itself two pounds of quick-lime were put on top of the filter early in 1892 but without beneficial effect, and later a pound of caustic potash in solu-

tion was applied. An analysis of the effluent four days later gave the following result: —

[Parts per 100,000.]

Color,	22.50
Free ammonia,	.9500
Albuminoid ammonia,	6.2000
Oxygen consumed,	36.00

The clogging was not reduced and the analysis of the effluent was so unsatisfactory that it was not considered advisable to continue the experiment.

This experiment has shown that soap is capable of completely clogging sand, thereby rendering it unfit for sewage purification. At the same time it must be borne in mind that the solution of soap applied during September contained one hundred times as much fatty acids as is usually carried by the sewage received at the Experiment Station, and the total quantity of soap applied was equivalent to thirty tons of soap on an acre. The clogging was mainly near the surface, as was shown by the following sand analyses Dec. 18, 1891: —

Analyses of Sand from Filter Tank No. 12 after applying Soap equivalent to Thirty Tons on an Acre.

Depth.	Water by Volume. Per Cent.	Loss on Ignition. Per Cent.	Fatty Acids. Per Cent.	Albuminoid Ammonia. Parts in 100,000.
0-6 inches,	26	1.43	0.46	23.0
6-12 "	15	0.97	0.21	9.0
12-24 "	11	-	0.03	4.0

The monthly averages of results for these filters are given in the following tables: —

Filter Tank No. 11.

Date.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Water.	Effluent.	Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.										
February,	51,400	41°	42°	.5280	.0580	1104.80	.7700*	.1240	-	996
March,	50,400	41°	43°	.2401	.0714	905.50	1.1000*	.0512	-	1,549
April,	52,000	45°	48°	.0099	.0132	593.00	1.4000*	.0118	-	1,097
May,	52,200	54°	57°	.0122	.0132	761.20	1.1000*	.0006	-	424
June,	50,000	60°	64°	.0137	.0118	799.00	1.9200	.0007	-	813
July,	52,200	66°	70°	.0120	.0125	742.20	1.8200	.0008	-	276
August,	50,400	65°	70°	.0075	.0134	851.40	1.8560	.0008	-	3,220
September,	52,000	66°	65°	.0041	.0101	838.00	1.7800	.0007	-	1,883
October,	46,400	58°	55°	.0047	.0084	599.00	1.9060	.0014	-	55,225
November,	50,000	50°	48°	.0033	.0075	623.00	1.7575	.0003	-	1,082
December,	52,200	42°	44°	.0012	.0152	102.00	1.4380	.0003	.21	628
1891.										
January,	50,400	40°	41°	.0014	.0105	5.51	1.8150	.0000	.12	364
February,	47,200	40°	44°	.0011	.0257	5.87	1.6925	.0501	.99	7,961
March,	31,000	39°	42°	.0049	.0325	5.75	.1490	.0015	.15	36,960
April,	36,000	43°	48°	.0138	.0175	5.87	.1450	.0002	.07	53,460
May,	50,400	51°	55°	.0072	.0120	5.91	.0575	.0158	.13	15,470
June,	52,000	59°	64°	.0150	.0264	6.31	.1618	.0020	.22	97,823
July,	52,200	65°	69°	.1050	.0285	6.19	1.4200	.0340	.18	911
August,	50,400	69°	71°	.0540	.0177	5.53	2.4000	.0170	.08	4,707
September,	52,000	67°	68°	.0076	.0106	5.33	2.2920	.0026	.08	6,164
October,	52,200	60°	67°	.0029	.0112	2.79	.9775	.0001	.03	939
November,	50,000	50°	51°	.0054	.0081	.35	.2075	.0000	.03	188
December,	52,200	46°	48°	.0009	.0067	.28	.1550	.0002	.04	90

City water applied six times a week, to which were added other substances, as follows: two parts per 100,000 of nitrogen as ammonia and a quantity of salt, as shown by the chlorine, until Dec. 3, 1890, when the application of salt was discontinued, but the amount of ammonia remained the same. From Feb. 18 to June 22, 1891, 100 parts of sugar were added to the ammonia. Beginning Oct. 12, 1891, city water only was applied.

Beginning Aug. 20, 1891, surface raked about 3 inches deep each week.

Experiments interrupted by high water in the river Oct. 20 to 22, 1890, Jan. 24 to 26, Feb. 27 to March 1, March 12 to 16, 23 to 29 and April 13 to 21, 1891.

* These nitrate determinations were made by the phenolsulphonic acid process, and owing to the excessive amount of chlorine the results are altogether too low. The later determinations were made by the aluminum process, which is not affected by the presence of chlorine. See report upon Purification of Sewage and Water, 1890, p. 714, also a paper "On the Determination of Nitrates in Water," by Allen Hazen and Harry W. Clark, Journal of Analytical and Applied Chemistry, V., 301.

Summary of Twenty Microscopical Examinations of Effluent of Filter Tank No. 11.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Synedra,	5	12	250
Algæ. Chlorococcus,	5	40	800
Fungi. Molds,	5	1	25
ANIMALS.			
Infusoria. Monas,	20	125	1,200

Filter Tank No. 12.

Date.	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.										
April,	52,000	45°	48°	.0039	.0144	7.71	2.3500	.0006	.08	641
May,	52,200	54°	57°	.0040	.0105	6.38	2.5700	.0005	.06	148
June,	50,000	60°	64°	.0025	.0076	5.35	2.0800	.0002	.04	88
July,	52,200	65°	70°	.0018	.0069	5.63	1.7000	.0001	.04	22
August,	50,400	69°	70°	.0017	.0102	5.55	1.3400	.0002	.06	218
September,	52,000	66°	65°	.0016	.0077	4.22	1.2625	.0001	.05	95
October,	46,400	58°	56°	.0010	.0060	5.66	1.1300	.0002	.06	287
November,	50,000	49°	49°	.0010	.0059	5.43	1.3025	.0000	.04	7,100
December,	52,200	43°	46°	.0007	.0053	5.43	.7840	.0001	.05	124
1891.										
January,	50,400	40°	45°	.0032	.0072	5.31	.6275	.0001	.06	120
February,	47,200	39°	45°	.0009	.0079	5.31	.9750	0002	.05	6
March,	31,000	39°	44°	.0030	.0043	4.75	1.8500	.0001	.03	6
April,	36,000	43°	48°	.0084	.0063	5.43	3.2900	.0001	.03	230
May,	50,400	51°	55°	.0008	.0044	5.25	2.5825	.0001	.02	65
June,	52,000	59°	64°	.0017	.0060	3.43	1.7960	.0005	.04	1
July,	52,200	65°	69°	.0025	.0046	3.98	1.6350	.0002	.04	36
August,	50,400	70°	71°	.0009	.0086	3.68	1.3283	.0000	.09	135
September,	50,000	67°	68°	.0161	.1027	3.15	.0040	.0001	2.17	15,580
October,	18,200	57°	57°	.0490	.0860	5.05	.4700	.0015	.84	34,650
November,	50,000	50°	51°	.2435	.0245	5.87	.5875	.0212	.23	288
December,	52,200	46°	49°	.1495	.0210	4.71	.9450	.0154	.20	809

City water applied six times a week, to which were added other substances as follows: until July 13, 1890, 2 parts per 100,000 of nitrogen as ammonia and 20 parts of sugar; July 14 to December 7, 2 parts of nitrogen and 40 parts of sugar; Dec. 8, 1890, to June 16, 1891, 2 parts of nitrogen and 100 parts of sugar; June 17 to August 10, city water applied alone; August 11 to September 2, 2 parts of nitrogen as ammonia and 90 parts of soap; September 3 to 29, 2 parts of nitrogen and 440 parts of soap; September 30 to October 12, nothing applied to tank; October 12 to 14, 90 parts of soap with ammonia as before; October 15 to December 27, city water applied with the ammonia only.

Beginning Aug. 20, 1891, surface raked about 3 inches deep each week.

Experiments interrupted by high water in the river Oct. 20 to 22, 1890, Jan. 24 to 26, Feb. 27 to March 1, March 12 to 16, 22 to 29, and April 13 to 21, 1891.

Summary of Thirteen Microscopical Examinations of Effluent of Filter Tank No. 12.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Unclassified,	8	6	75
Algæ. Ulothrix,	8	2	25
Fungi. Crenothrix,	15	10	100
ANIMALS.			
Infusoria. Monas,	15	33	300
Vermes. Unclassified,	8	2	25

FILTER TANK No. 13.

Tank No. 13 has continued filtering a solution of ammonia with enough soda to combine with the nitric acid formed. The nitrification has been in the main very complete, and a large percentage of the nitrogen of the applied ammonia has appeared in the effluent as nitrates. The principal object in continuing this filter without change of dose was to afford an opportunity for the study of the relation of various bacteria to nitrification. These studies, as yet incomplete, have more bearing upon the filtration of water than of sewage and will be discussed in connection with purification of water.

The average monthly results are as follows: —

Filter Tank No. 13.

Date.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Water.	Effluent.	Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.										
April,	52,000	45°	48°	3.2250	-	77.20	20.5000	7.3450	7.65	2,964
May,	52,200	55°	54°	.9375	.0223	71.40	27.6000	.1052	.19	1,686
June,	50,000	64°	64°	.7900	.0164	73.10	23.1875	.0042	.10	262
July,	52,200	72°	70°	.2294	.0194	74.60	21.5000	.0055	.19	9,621
August,	50,400	73°	71°	.0725	.0187	69.90	22.6800	.0034	.16	5,020
September,	52,000	68°	66°	.0177	.0098	70.70	23.6250	.0017	.08	442
October,	46,400	58°	55°	.0170	.0072	71.40	16.3400	.0019	.08	1,763
November,	50,000	47°	49°	.0252	.0059	71.75	25.6500	.0012	.06	455
December,	52,200	38°	46°	1.2482	-	70.84	23.9000	.0077	.06	92
1891.										
January,	50,400	36°	45°	.2820	.0119	70.08	26.5500	.0015	.07	128
February,	47,200	37°	45°	.0294	.0116	70.72	26.2750	.0021	.12	67
March,	31,000	38°	43°	.0365	.0108	63.33	24.5667	.0020	.08	224
April,	36,000	47°	48°	.0262	.0107	71.30	27.0000	.0020	.10	540
May,	50,400	56°	58°	.0120	.0109	70.88	25.2750	.0022	.09	444
June,	52,000	66°	65°	.0073	.0298	38.90	14.4750	..0007	.18	4,562
July,	52,200	70°	70°	.0067	.0180	50.24	17.6725	.0017	.12	230
August,	50,400	71°	71°	.0051	.0114	70.62	26.2000	.0003	.07	192
September,	52,000	67°	68°	.0027	.0126	69.68	25.0000	.0003	.13	336
October,	52,200	51°	57°	.0044	.0107	69.87	25.8250	.0401	.15	227
November,	50,000	44°	52°	.0132	.0348	71.52	25.1250	.0003	.04	126
December,	52,200	42°	49°	.0129	.0093	71.20	25.8500	.0004	.09	134

City water applied six times a week till May 15, 1890, to which were added 28 parts of nitrogen as ammonia, with enough sodium carbonate to form nitrate with the nitrogen present.

Beginning May 16, 1890, effluent from Tank 8 was applied six times a week, to which was added the above dose, excepting from June 17 to July 7, when water only was applied.

Experiments interrupted by high water in the river Oct. 20 to 22, 1890, Jan. 24 to 26, Feb. 27 to March 1, March 12 to 16, 22 to 29, and April 13 to 21, 1891.

Summary of Seventeen Microscopical Examinations of Effluent.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ. Conferva,	6	12	200
Fungi. Molds,	6	12	200
ANIMALS.			
Infusoria. Monas,	12	18	200
Vermes. Rotatorian ova,	6	6	100

FILTER TANK No. 14.

This small filter of coarse No. 1 sand and the various experiments made with it were fully described in the report upon the Purification of Sewage and Water (pages 122, 685 and 730). During 1889 an air-tight cover was kept upon the filter and the admission of air was limited. From Dec. 7, 1889, no air was admitted, and no nitrification and very little oxidation or purification took place. On March 10, 1890, the cover was removed; nitrification commenced at once, and in a month the ammonia was reduced to .0048 part per 100,000 with 2.25 parts nitrates, the dose being 51,400 gallons per acre daily, and good results were regularly obtained thereafter. The quantity was increased June 18 to 85,700 gallons; December 4, to 103,000 gallons, and January 1 to 120,000 gallons, which was continued with good result until May 19, when it was again increased to 134,000 gallons per acre daily. At first a good result was obtained, but in the latter part of June the surface became clogged and nitrification was imperfect. On July 2 the surface was turned under three inches deep.

It was desired to determine accurately how much water the filter retained when completely drained, to see what effect the prolonged use had made. For this purpose city water was added until the salt of the sewage had been all washed out, and afterward a solution of salt in city water. The entire effluent for each day was collected and mixed and chlorine determination made, from which it was possible to calculate with great accuracy the proportion of salted water in the effluent for each day and the total amount of water held by the sand. The amount held was found to be 12.6 gallons when drained twenty-four hours, and 12 gallons after forty-eight hours. The amount held by Tank 13, filled with the same material, but which had been used for other experiments, which had

not to any considerable extent dirtied the sand, was 8 gallons. The original material may have held somewhat less than this when perfectly clean. The increase in water capacity from 7 or 8 gallons in the original material to 12.6 gallons after three years' use for sewage purifications may be attributed to the storage of organic matters on the sand grains, rendering them sticky and retentive of moisture. The bearing of these facts has already been discussed, page 439.

These experiments were continued through July during which time either eight or three gallons of city water were applied daily, either with or without a definite amount of common salt.

It was evident from the experience of June that the upper layer of sand was so clogged that renewed application of sewage in large quantity would be unsuccessful unless some change was made, and it was decided to invert the upper foot of sand to see if that would allow a better result. This was accordingly done July 29, by taking out the first six inches, then the second six inches, and replacing the two portions in the inverse order.

A series of sand samples before changing gave the following results: —

Depth Below Surface.	Water by Volume. — Per Cent.	Albuminoid Ammonia. — Parts in 100,000.
0-6 inches,	32.5	50.
6-12 "	20.5	12.
12 "	20.7	7.6
24 "	13.7	2.9
36 "	10.1	2.1
48 "	11.3	1.9

The upper six inches then contained four times as much stored organic matter as the six inches next below and the inversion reduced the clogging material in the upper six inches by three-fourths. The dirty sand did not pack so closely as it had been packed when clean, — the twelve inches occupying thirteen inches after making the change.

Commencing July 31, sewage was again applied at the rate of 137,000 gallons per acre daily. The effluent contained much more organic matter during the following months than under comparable

conditions before the sand had become clogged; still the results were quite satisfactory throughout the year, and improved slightly from month to month.

It may be added, however, that in March, 1892, the sand again became clogged, and that a reinversion of the upper foot of sand failed to again restore the filter to a good working condition, a removal of the dirty sand being found necessary for this purpose.

The average results for the past two years are shown in the following table. The two periods November, 1889, to March, 1890, when air was artificially excluded (which was discussed in the report upon the Purification of Sewage and Water, page 730), and July, 1891, when Merrimack River water was applied as described above, are not included: —

Average Result of Analyses of Sewage and Effluent from Filter Tank No. 14.

	Quantity of Sewage Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.		Nitrates.	Nitrites.		
April — June, 1890:								
Sewage,	56,000	1.7127	.6060	5.03	0	0	2.79	480,000
Effluent,	55,800	.0188	.0244	4.84	2.45	.0025	.13	2,124
July, 1890, — June, 1891:								
Sewage,	105,000	1.8649	.6615	6.03	0	0	3.18	1,010,000
Effluent,	105,000	.0164	.0246	5.50	1.70	.0013	.20	11,300
August — December, 1891:								
Sewage,	137,000	2.7834	.8719	8.27	0	0	4.53	858,572
Effluent,	135,000	.0247	.0400	7.69	2.51	.0021	.31	33,568

The results of the weekly analyses are given in full in the following table: —

Filter Tank No. 14.

Week Ending—	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Feb. 22,	51,429	45°	40°	-	Feb. 21,	1.2500	.0900	5.12	.6500	.0200	-	-
March 1,	51,429	45°	44°	-	25,	1.1000	.0800	5.62	1.0000	.0280	-	-
					28,	.9000	.1100	4.62	.0000	.0600	-	-
8,	51,429	43°	40°	-	March 7,	.6500	.1000	4.02	.0000	.0000	.90	-
15,	51,429	45°	45°	-	14,	.9000	.0700	4.19	1.0000	.0220	.35	4,680
22,	51,429	45°	43°	-	21,	.4200	.0400	3.84	2.6000	.0400	-	646
29,	51,429	45°	43°	-	28,	.0800	.0500	4.39	1.7500	.0006	.18	1,320
April 5,	51,429	45°	46°	-	April 4,	.0115	.0245	4.40	1.6000	.0080	.17	3,186
12,	51,429	45°	46°	-	11,	.0048	.0201	4.76	2.2500	.0060	.18	462
19,	51,429	46°	49°	-	18,	.0068	.0222	4.57	2.5000	.0050	.14	1,296
26,	51,429	46°	49°	-	25,	.0048	.0174	4.02	2.2500	.0024	.13	1,976
May 3,	51,429	48°	51°	-	May 2,	.0026	.0142	4.29	2.2500	.0020	.14	1,375
10,	51,429	51°	55°	-	9,	.0034	.0180	4.32	2.5000	.0016	.12	962
17,	51,429	54°	59°	-	16,	.0022	.0152	4.40	3.1000	.0010	.10	1,170
24,	51,429	56°	60°	-	23,	.0048	.0144	5.56	3.5000	.0016	.12	1,539
31,	51,429	58°	59°	-	30,	.0034	.0146	5.19	2.6000	.0006	.11	-
June 7,	51,429	59°	60°	-	June 6,	.0032	.0160	5.02	2.6000	.0006	.12	1,065
14,	51,429	61°	61°	-	13,	.0036	.0144	5.07	2.1000	.0003	.09	28
21,	74,286	64°	66°	-	20,	.0146	.0240	5.72	2.7500	.0016	.13	9,794
28,	85,714	71°	69°	-	27,	.0046	.0264	5.47	2.2500	.0008	.13	2,640
July 5,	85,714	72°	71°	-	July 4,	.0060	.0274	6.66	2.2500	.0008	.12	8,556
12,	85,714	72°	69°	-	11,	.0040	.0224	5.96	2.5000	.0006	.11	6,822
19,	85,714	73°	71°	-	18,	.0048	.0260	6.42	2.5000	.0010	.10	8,100
26,	85,714	71°	67°	-	25,	.0036	.0224	5.72	2.2500	.0006	.13	12,449
Aug. 2,	85,714	73°	74°	-	Aug. 1,	.0036	.0258	5.77	2.5000	.0014	.14	-
9,	85,714	76°	74°	-	8,	.0032	.0282	6.18	2.4000	.0012	.12	-
16,	85,714	73°	69°	-	15,	.0044	.0272	11.10	2.6000	.0012	.13	-
23,	85,714	72°	69°	-	22,	.0038	.0220	10.37	2.6500	.0008	.12	-
30,	85,714	67°	68°	-	29,	.0040	.0228	8.57	1.9000	.0008	.11	-
Sept. 6,	85,714	66°	67°	-	Sept. 5,	.0076	.0222	5.28	2.1500	.0004	.12	-
13,	85,714	68°	67°	-	12,	.0018	.0288	5.24	2.2500	.0000	.17	-
20,	85,714	66°	67°	-	19,	.0044	.0188	5.64	2.4200	.0006	.15	890
27,	85,714	62°	63°	-	26,	.0048	.0192	5.42	2.1500	.0006	.16	16,200

Sewage applied six times a week.
Air excluded until March 10, when the cover was removed and the trap taken from the outlet.
Effluent very turbid until March 7; slightly turbid March 14 and 21; afterwards clear.

FILTER TANK NO. 14 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Oct. 4,	85,714	60°	62°	-	Oct. 3,	.0046	.0216	6.52	2.4000	.0012	.19	13,080
11,	85,714	59°	56°	-	10,	.0052	.0204	5.22	1.5000	.0022	.21	6,195
18,	85,714	54°	55°	-	17,	.0530	.0398	5.76	1.2500	.0200	.31	81,202
25,	42,857	49°	50°	-	24,	.0096	.0266	4.94	2.2000	.0004	.19	20,640
Nov. 1,	85,714	47°	49°	-	31,	.0018	.0280	5.92	1.7500	.0008	.27	27,240
8,	85,714	45°	50°	-	Nov. 7,	.0032	.0248	5.31	2.2000	.0006	.17	26,550
15,	85,714	45°	48°	-	14,	.0038	.0292	6.50	2.2000	.0006	.24	8,280
22,	85,714	42°	47°	-	21,	.0056	.0234	5.67	2.0000	.0004	.21	5,880
29,	85,714	40°	47°	-	28,	.0038	.0224	5.47	1.8700	.0004	.18	11,880
Dec. 6,	94,286	45°	46°	-	Dec. 5,	.0048	.0264	5.82	1.5100	.0007	.18	6,120
13,	102,857	45°	47°	-	12,	.0018	.0164	6.00	1.5000	.0002	.16	4,860
20,	102,857	45°	45°	-	19,	.0010	.0214	7.57	1.2900	.0000	.17	5,640
27,	102,857	45°	46°	-	26,	.0010	.0216	4.70	1.3500	.0002	.18	820
1891.												
Jan. 3,	111,429	45°	44°	-	30,	.0014	.0142	4.19	1.4100	.0001	.14	2,400
10,	120,000	45°	45°	-	Jan. 6,	.0018	.0162	4.52	1.3800	.0003	.13	3,300
17,	120,000	46°	45°	-	13,	.0022	.0144	3.20	1.4400	.0002	.24	1,120
24,	120,000	45°	46°	-	20,	.0016	.0130	3.42	1.2600	.0001	.14	448
31,	100,000	44°	43°	-	27,	.0052	.0232	4.40	.7500	.0006	.18	2,400
Feb. 7,	120,000	44°	43°	-	Feb. 3,	.0016	.0204	4.90	1.2300	.0001	.20	960
14,	120,000	44°	43°	-	10,	.0036	.0156	6.08	1.0600	.0004	.21	200
21,	120,000	44°	44°	-	17,	.0032	.0246	5.60	1.0000	.0005	.23	8,280
28,	80,000	44°	45°	-	24,	.0018	.0236	4.45	.8600	.0005	.18	3,900
March 7,	120,000	44°	41°	-	March 3,	.0040	.0234	2.72	1.1700	.0016	.21	6,840
14,	60,000	45°	45°	-	10,	.0020	.0240	4.72	1.2300	.0004	.20	9,540
21,	100,000	44°	42°	-	-	-	-	-	-	-	-	-
28,	0	-	-	-	-	-	-	-	-	-	-	-
April 4,	120,000	45°	45°	-	31,	.0042	.0228	3.92	2.0200	.0004	.17	12,600
11,	120,000	44°	45°	-	April 7,	.0042	.0208	3.45	.9200	.0002	.21	8,640
18,	0	-	-	-	-	-	-	-	-	-	-	-
25,	80,000	52°	53°	-	-	-	-	-	-	-	-	-

Sewage applied six times a week.

Surface raked about 1 inch deep each week from October 15 to February 19, afterwards about 3 inches deep each week.

Experiments interrupted by high water in the river October 20 to 22, January 25, 26, February 27, 28, March 1, 12 to 16, 23 to 29, April 12 to 18, 20 and 21.

Effluent clear or very slightly turbid.

FILTER TANK NO. 14 — *Continued.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.												
May 2,	120,000	50°	52°	-	April 28,	.0216	.0288	4.38	1.7200	.0005	.21	16,020
9,	120,000	50°	51°	-	May 5,	.0014	.0250	4.32	1.6700	.0001	.21	11,160
16,	120,000	56°	56°	-	12,	.0044	.0254	5.14	2.0200	.0006	.21	12,200
23,	134,287	55°	57°	-	19,	.0020	.0266	2.93	1.7600	.0003	.25	48,000
30,	134,287	60°	59°	-	26,	.0060	.0218	4.45	1.9800	.0014	.21	21,600
June 6,	134,287	63°	60°	-	June 2,	.0062	.0282	4.87	2.4200	.0012	.26	14,580
13,	134,287	64°	65°	-	9,	.0114	.0234	5.48	2.2800	.0016	.21	15,840
20,	134,287	70°	65°	-	16,	.2500	.0620	13.37	.4800	.0140	.53	18,720
27,	134,287	67°	66°	-	23,	.2300	.0480	10.23	.4700	.0080	.45	260
July 4,	134,287	67°	66°	-	30,	.1910	.0540	6.24	.1900	.0044	.53	580
11,	134,287	67°	66°	-	July 7,	.1560	.0240	15.40	.5300	.0044	.23	-
18,	94,286	73°	72°	-	14,	.0160	.0388	.75	1.1000	.0012	.21	-
25,	51,429	68°	70°	-	21,	.0220	.0188	12.00	2.1800	.0050	.15	-
Aug. 1,	134,287	69°	67°	-	28,	.0046	.0250	27.60	1.7600	.0006	.18	8,100
8,	134,287	70°	69°	-	Aug. 4,	.0262	.0460	5.28	2.2700	.0024	.24	50,000
15,	134,287	74°	73°	-	11,	.0460	.0540	7.33	2.7300	.0044	.31	43,000
22,	134,287	73°	71°	-	18,	.0840	.0640	6.12	3.1000	.0040	.39	70,740
29,	134,287	73°	70°	-	25,	.0284	.0404	8.60	2.9600	.0012	.25	43,862
Sept. 5,	134,287	67°	66°	-	Sept. 1,	.0440	.0400	6.68	2.4600	.0120	.34	23,510
12,	134,287	65°	65°	-	8,	.0240	.0480	10.88	2.7100	.0016	.39	38,520
19,	134,287	67°	67°	-	15,	.0020	.0400	6.23	2.4200	.0016	.33	41,760
26,	134,287	69°	69°	-	22,	.0302	.0228	12.86	3.2800	.0010	.25	4,180
Oct. 3,	134,287	69°	66°	-	29,	.0440	.0640	10.80	3.2600	.0060	.43	-
10,	134,287	65°	61°	-	Oct. 6,	.0440	.0480	9.58	2.7300	.0016	.34	63,540
17,	134,287	56°	56°	-	13,	.0170	.0430	8.93	2.3700	.0018	.37	13,500
24,	134,287	51°	54°	-	20,	.0094	.0258	7.09	2.3700	.0002	.25	-
31,	134,287	46°	52°	-	27,	.0560	.0540	9.55	2.4300	.0012	.31	24,480
Nov. 7,	134,287	45°	48°	-	Nov. 3,	.0106	.0264	6.78	2.2800	.0012	.29	-
14,	134,287	45°	53°	-	10,	.0076	.0384	6.48	2.4100	.0009	.30	30,000
21,	134,287	46°	51°	-	17,	.0088	.0346	6.20	2.8600	.0008	.32	102,000
28,	134,287	43°	50°	-	24,	.0108	.0328	5.98	2.1000	.0018	.30	500

Sewage applied six times a week.
Surface raked about 3 inches deep each week.
July 29, surface inverted 1 foot deep.
City water, sometimes with salt added, applied July 2 to 31, to determine the water capacity.
Effluent generally slightly turbid.

FILTER TANK NO. 14 — *Concluded.*

WEEK ENDING —	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE.		Sewage remained on Surface.	Date of Sample.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.												
Dec. 5,	134,287	40°	49°	1h. 52m.	Dec. 1,	.0054	.0232	7.28	2.6400	.0001	.22	4,400
12,	134,287	44°	50°	24m.	8,	.0078	.0328	6.80	1.9900	.0006	.29	26,600
19,	134,287	45°	46°	7m.	15,	.0094	.0284	7.62	2.1000	.0020	.30	11,000
26,	134,287	45°	49°	6m.	22,	.0074	.0388	6.86	2.0000	.0010	.31	3,100
-	-	-	-	-	29,	.0072	.0288	6.25	2.4300	.0008	.30	9,600

Sewage applied six times a week.
Surface raked about 3 inches deep each week.
Effluent very slightly turbid and nearly colorless.

Summary of Twenty-three Microscopical Examinations of Effluent.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ. Chlorococcus,	9	2	125
Fungi.			
Crenothrix,	13	245	3,000
Molds,	9	2	25
Saccharomyces,	4	1	25
ANIMALS.			
Infusoria.			
Monas,	17	28	500
Paramæcium,	9	38	500
Vermes.			
Anguillula,	4	4	100
Unclassified,	4	4	100

Sand Analyses.

DATE.	Depth, Inches.	WATER BY		AMMONIA.*		Total Nitrogen.*	Bacteria per Gram.
		Weight.	Volume.	Free.	Albuminoid.		
1891.		Per Cent.	Per Cent.				
July 29,	0-6	16.9	32.5	-	50.0	82.4	-
	6-12	11.4	20.5	-	12.0	19.8	-
	12	11.5	20.7	-	7.6	12.6	-
	24	7.9	13.7	-	2.9	4.9	-
	36	5.9	10.1	-	2.1	3.5	-
	48	6.6	11.3	-	1.9	3.1	-
November 18,	0-6†	11.5	19.5	1.0	33.5	64.2	2,000,000.
	6-12†	15.0	26.5	1.3	28.8	48.5	196,000.
	12-24	8.4	14.7	0.5	7.2	12.3	240,000.
	30	7.6	13.2	0.3	4.4	7.5	100,000.

* Parts in 100,000. † Actually 6½ inches, representing 6 inches of original material.

The amounts of nitrogen stored in the various layers, as determined after inverting the upper foot July 29 and at the later date, were as follows, in pounds: —

Depth Below Surface.	July 29.	November 18.	Increase.
0-6 inches,	.0223	.0630	.0407
6-12 inches,	.0927	.0546	.0381*
12-24 inches,	.0177	.0276	.0099
Below 24 inches,	.0225	.0327	.0102
Total,	.1552	.1779	.0227

* Decrease.

The original sand of Filter 14 contained .0114 pound of nitrogen, and on April 2, 1889, seven pounds of slime were removed from the surface. The exact quantity of nitrogen contained in this is unknown, but from examination of other slimes we may conclude that it had at least .0120 pound nitrogen, an amount equal to the nitrogen of the original sand. We can take, then, the figures for total nitrogen in the filter as closely representing the amount stored. The distribution of the total nitrogen applied is as follows: —

	Total Nitrogen.					
	Applied to Date.	In Effluent to Date.	Stored in Sand to Date.	Lost.	Per Cent. Stored in Sand.	Per Cent. Lost.
July 29, 1891,	1.2183	.7028	.1552	.3603	13	29
Nov. 18, 1891,	1.3819	.8315	.1779	.3725	13	27

During the period between the two sets of analyses .0420 pound of nitrogen as sludge was applied with sewage, and the increase in nitrogen in the upper six inches was .0407. The six inches next below, that is, the old surface, showed a decrease of .0381, but the increase in the lower part of the filter suggests that fully one-half of this was caused by mechanical washing down of the stored organic matters by the rapid flow of sewage which took place after making the inversion.

FILTER TANK No. 15 A.

This small filter five feet deep, of large gravel stones about one inch in diameter, was described in the report upon the Purification of Sewage and Water (pages 549 and 686). At first it was used for sewage purification, giving a good result with 17,000 gallons per acre daily, applied in nine small portions. Commencing Oct. 22, 1889, sulphuric acid was mixed with the applied sewage, checking nitrification but still allowing the removal of more than three-fourths of the organic matters. The effect of acid is in many respects similar to that of frost; the oxidation of ammonia is prevented, but the first part of the process of purification — the oxidation to ammonia and carbonic acid — is not checked to a corresponding extent. The purification was good when compared with that obtained by chemical precipitation, but was far less complete than had previously been obtained without the acid. By experiments with another filter, No. 17 A, we have learned how to treat acid sewage with as good a result as can be obtained from normal sewage, by using a certain amount of lime-stone in the filtering material.*

Commencing Oct. 27, 1890, the acid was omitted from the dose, but the stones of the filter were so thoroughly saturated with acid, which was only slowly removed, that a long time elapsed before the full effect of the change was felt. During November and December the organic matters in the effluent were gradually reduced, until on Jan. 6, 1891, the albuminoid ammonia was .0380 part per 100,000 and the oxygen consumed .20. There was no further substantial change in this respect in the effluent. Purification was thus completely established in two months after ceasing to apply acid and as soon as the reaction of the effluent was neutral. It was different with nitrification; in January the excess of acid was removed, but there was no excess of alkali to combine with any nitric acid which might be produced by nitrification. Sewage is slightly alkaline, but apparently a large part of the alkali of the sewage was required to neutralize acid which was still slowly washing out of the stones. The effluent was always exactly neutral; nitrification always proceeded just as far as alkali could be obtained for the acid formed, and no farther. In no other way can we explain

* Pages 448 and 563.

the extremely slow and regular decrease in ammonia and increase in nitrates, extending over a period of nine months, from January to September, 1891. The fact that practically all the nitrogen of the effluent at the end of that period was in the form of nitrates shows conclusively that ordinary sewage carries enough alkali for its own nitrification, but the extreme slowness with which the acid remaining in the stones was overcome indicates that there is very little excess.

Commencing Oct. 12, 1891, an attempt was made to increase the capacity of the filter by applying smaller quantities of sewage at shorter intervals. The difficulty of getting satisfactory automatic distribution of very small quantities of sewage on such an extremely coarse material, even in experimental work, has proved to be very great, and was probably the chief reason for the comparatively imperfect results obtained with this treatment.

The following table shows the work of the filter for the past two years. In the first period the sewage was made strongly acid with sulphuric acid. In the second, no acid was added, but the old acid clinging to the stones still kept the filter acid and the results were only slightly better than in the preceding period. In the third, the excess of acid was removed and the effluent was either neutral, or, toward the last, slightly alkaline, and good purification with constantly increasing nitrification was obtained. The increased number of bacteria in this period was probably due to the removal of the sterilizing action of the acid. In the last period of three months, with an increased total dose applied automatically in very small single doses, less satisfactory results were obtained, the organic matters as shown by the albuminoid ammonia and oxygen consumed being five times as great as in the preceding period.

Average Results of Analyses of Sewage and Effluent of Filter Tank No. 15 A.

		Quantity. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
January — October, 1890,	Sewage,	17,100	1.8190	.6622	5.48	0	0	3.11	1,103,000
Acid sewage,	Effluent,	-	2.1675	.1253	6.66	.07	.0010	.61	1,864
November — December, 1890,	Sewage,	17,100	1.8244	.8065	5.31	0	0	3.83	1,016,000
Sewage alkaline, filter acid,	Effluent,	-	1.2683	.1061	6.34	.05	.0006	.44	1,623
January — September, 1891,	Sewage,	19,700	2.0300	.6490	7.16	0	0	3.15	691,000
Filter neutral or alkaline,	Effluent,	-	.7518	.0368	7.08	2.00	.0021	.18	14,500
October — December, 1891,	Sewage,	36,000	2.7893	.9709	8.00	0	0	5.12	700,000
	Effluent,	-	.6578	.1859	8.40	2.32	.0610	.87	59,000

The weekly results are shown in the following table: —

FILTER TANK NO. 15 A.

Week Ending—	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
March 8,	17,143	48°	39°	March 7,	1.5000	.0900	5.05	.0400	.0008	.48	-
15,	17,143	45°	44°	14,	1.2500	.0800	4.22	.0600	.0020	.43	561
22,	17,143	45°	43°	21,	1.6000	.0800	4.27	.0600	.0020	-	64
29,	17,143	45°	42°	28,	1.4000	.0700	4.95	.0500	.0018	.49	54,560
April 5,	17,143	46°	46°	April 4,	1.5000	.1300	5.07	.0800	.0018	.43	1,782
12,	17,143	45°	46°	11,	2.0000	.0700	5.12	.0800	.0020	.53	868
19,	17,143	45°	50°	18,	1.8500	.1500	5.70	.0700	.0020	.42	-
26,	17,143	46°	50°	25,	1.9500	.1600	5.49	.1100	.0022	.41	-
May 3,	17,143	48°	52°	May 2,	2.1000	.1800	5.75	.1000	.0010	.50	35
10,	17,143	52°	56°	9,	2.2000	.1500	5.45	.1600	.0018	.39	38
17,	17,143	56°	59°	16,	3.0000	.1100	5.66	.1800	.0018	.62	123
24,	17,143	58°	60°	23,	3.0000	.1300	5.76	.1600	.0018	.71	31
31,	17,143	58°	59°	30,	2.6500	.1200	5.81	.1100	.0012	.61	-
June 7,	17,143	61°	60°	June 6,	3.0000	.1000	6.25	.0600	.0004	.57	-
14,	17,143	62°	60°	13,	3.0000	.1400	6.33	.0500	.0004	.55	6
21,	17,143	64°	66°	20,	3.5000	.1500	6.87	.0500	.0006	.57	-
28,	15,714	71°	69°	27,	2.9000	.2000	7.65	.0500	.0008	.50	-
July 5,	17,143	72°	71°	July 4,	2.7500	.1200	8.65	.1400	.0010	.49	571
12,	15,714	72°	70°	11,	3.2500	.1800	10.09	.0600	.0004	.41	1,961
19,	17,143	73°	71°	18,	2.6500	.1500	10.68	.0700	.0006	.45	29
26,	17,143	71°	68°	25,	2.7000	.1700	10.12	.0700	.0004	.51	49
Aug. 2,	17,143	73°	74°	Aug. 1,	2.6500	.1100	7.75	.0500	.0006	.50	139
9,	17,143	76°	74°	8,	2.5000	.1600	7.79	.0700	.0006	.75	68
16,	17,143	73°	70°	15,	2.3500	.1900	9.05	.0300	.0006	.82	356
23,	17,143	72°	70°	22,	2.8500	.1600	8.50	.0300	.0004	.93	261
30,	17,143	67°	68°	29,	2.2500	.1400	9.20	.0400	.0004	.64	-
Sept. 6,	17,143	66°	68°	Sept. 5,	2.3500	.1500	10.45	.0300	.0006	.83	-
13,	17,143	68°	68°	12,	2.3500	.1400	9.25	.0300	.0006	.74	-
20,	17,143	66°	68°	19,	2.7000	.1300	7.25	.0200	.0002	.72	81
27,	17,143	62°	63°	26,	2.8000	.1900	8.44	.0300	.0002	.86	301
Oct. 4,	17,143	60°	62°	Oct. 3,	2.1500	.1400	8.20	.0200	.0002	.86	381

Sewage, to which was added sulphuric acid equivalent to 22.5 parts per 100,000, applied 12 times a week till July 30; afterwards the dose of acid was doubled.

Effluent generally slightly turbid.

FILTER TANK NO. 15 A — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
Oct. 11, .	17,143	59°	54°	Oct. 10, .	2.2500	.2000	8.25	.0200	.0001	1.12	20
18, .	17,143	54°	55°	17, .	2.3500	.2000	7.20	.0400	.0002	.86	21
25, .	10,000	49°	50°	24, .	2.2500	.1500	6.20	.0200	.0002	.84	113
Nov. 1, .	17,143	47°	49°	28, .	1.9000	.1300	6.65	.0200	.0004	.74	1,320
				31, .	1.8500	.1100	6.78	.0100	.0002	.65	2,124
8, .	17,143	45°	50°	Nov. 4, .	1.8500	.0500	6.43	.0000	.0002	.45	31
				7, .	1.5000	.0900	3.68	.0000	.0000	.25	562
15, .	17,143	45°	48°	11, .	1.6500	.1500	7.60	.0600	.0000	.35	130
				14, .	1.1000	.1000	7.80	.0600	.0000	.40	148
22, .	17,143	42°	47°	21, .	1.2500	.1900	6.47	.0200	.0004	.48	480
29, .	17,143	40°	47°	28, .	1.1500	.0700	6.04	.0900	.0004	.38	1,040
Dec. 6, .	17,143	45°	46°	Dec. 5, .	1.1000	.1200	7.87	.0500	.0004	.50	960
13, .	17,143	46°	47°	12, .	1.1000	.1100	6.58	.0600	.0004	.53	1,440
20, .	17,143	45°	44°	19, .	1.1000	.1100	6.50	.0300	.0010	.39	1,540
27, .	15,714	45°	46°	26, .	1.2000	.0940	5.42	.0800	.0010	.57	10,200
1891.											
Jan. 3, .	20,914	45°	44°	31, .	1.1000	.0860	5.32	.1000	.0014	.50	108
10, .	19,714	45°	45°	Jan. 6, .	1.2000	.0380	5.84	.0400	.0003	.20	1,020
17, .	19,714	46°	45°	13, .	1.2000	.0360	5.24	.0600	.0002	.17	7,080
24, .	18,257	45°	46°	20, .	1.1400	.0420	4.37	.0600	.0009	.18	18,000
31, .	16,429	44°	42°	27, .	1.1200	.0480	4.47	.1200	.0012	.20	32,400
Feb. 7, .	19,714	44°	43°	Feb. 3, .	1.0000	.0580	4.69	.1900	.0016	.29	4,500
14, .	19,714	44°	42°	10, .	1.2400	.0380	5.82	.1700	.0024	.20	11,754
21, .	19,714	45°	43°	17, .	1.3000	.0500	5.38	.2800	.0036	.21	18,540
28, .	13,143	44°	45°	24, .	1.0000	.0360	5.02	.8900	.0060	.17	10,800
March 7, .	19,714	44°	40°	March 3, .	1.3000	.0440	4.15	.6500	.0080	.20	21,600
14, .	9,486	44°	44°	10, .	1.0000	.0380	4.27	1.1800	.0080	.16	14,400
21, .	16,057	44°	41°	-	-	-	-	-	-	-	-
28, .	0	-	-	-	-	-	-	-	-	-	-
April 4, .	19,714	45°	45°	31, .	1.2000	.0520	4.40	1.5200	.0064	.11	1,040

Sewage, to which was added sulphuric acid equivalent to 45 parts per 100,000, applied 12 times a week till October 25; then sewage alone applied 12 times a week till December 31; afterwards 54 times a week.

Surface raked about 1 inch deep each week, beginning December 25.

Experiments interrupted by high water in the river October 20 to 22, January 25, 26, February 27 to March 2, March 12 to 16, 23 to 29.

Effluent generally quite turbid until February 10; afterwards, slightly turbid.

FILTER TANK No. 15 A — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
April 11,	19,714	44°	44°	April 7,	1.1000	.0320	4.42	2.5300	.0050	.16	18,000
18,	1,086	-	-	-	-	-	-	-	-	-	-
25,	13,143	52°	52°	-	-	-	-	-	-	-	-
May 2,	19,714	50°	52°	28,	1.2000	.0360	5.35	1.5100	.0034	.16	21,600
9,	19,714	50°	51°	May 5,	1.0000	.0460	5.37	1.7000	.0012	.15	30,240
16,	19,714	56°	55°	12,	.8000	.0360	5.47	2.0700	.0006	.12	25,200
23,	19,714	55°	57°	19,	.6600	.0300	6.08	1.8700	.0008	.20	74
30,	19,714	60°	58°	26,	.6800	.0280	6.92	2.3700	.0008	.16	36,720
June 6,	19,714	63°	60°	June 2,	.7000	.0400	6.70	2.7400	.0003	.14	42,300
13,	19,714	64°	65°	9,	.5500	.0300	7.33	2.5400	.0001	.14	29,700
20,	19,714	70°	65°	16,	.7500	.0320	10.08	2.9000	.0016	.15	3,660
27,	19,714	67°	66°	23,	.5000	.0340	9.92	3.0200	.0000	.17	440
July 4,	19,714	66°	66°	30,	.4200	.0400	9.88	2.7400	.0000	.27	500
11,	19,714	67°	67°	July 7,	.3800	.0340	9.80	3.0000	.0000	.16	840
18,	19,714	73°	73°	14,	.4000	.0300	7.86	3.1000	.0000	.22	8,800
25,	19,714	73°	70°	21,	.3900	.0280	13.28	2.8500	.0006	.17	-
Aug. 1,	19,714	70°	67°	28,	.3800	.0340	14.50	3.0800	.0003	.14	11,160
8,	19,714	70°	70°	Aug. 4,	.2800	.0300	10.10	3.0700	.0004	.15	14,000
15,	19,714	74°	74°	11,	.3500	.0240	8.48	2.9200	.0006	.19	-
22,	19,714	74°	71°	18,	.2800	.0300	7.35	3.3800	.0005	.19	27,900
29,	19,714	73°	72°	25,	.1700	.0260	8.43	3.1600	.0014	.21	4,060
Sept. 5,	19,714	68°	67°	Sept. 1,	.1200	.0360	7.55	3.3300	.0008	.19	23,040
12,	19,714	65°	65°	8,	.1000	.0360	10.19	3.0000	.0016	.25	21,780
19,	19,714	67°	67°	15,	.0800	.0340	7.90	3.1000	.0010	.17	7,960
26,	19,714	69°	70°	22,	.2200	.0440	9.12	3.7800	.0007	.21	4,040
Oct. 3,	19,714	69°	66°	29,	.0940	.0360	11.48	4.1000	.0016	.21	-
10,	19,714	66°	62°	Oct. 6,	.1300	.0380	9.78	3.6200	.0100	.27	6,640
17,	40,086	-	56°	13,	.8300	.1880	9.00	2.2900	.0300	.68	17,460
				16,	1.2000	.3400	7.83	1.4500	.0900	1.40	25,760
24,	39,943	-	54°	20,	1.1000	.3400	7.48	1.6400	.1800	1.20	70,200
				23,	1.1000	.3000	6.96	1.9800	.2200	1.60	34,875
31,	45,714	-	51°	27,	1.1500	.3400	12.47	1.5500	.4000	1.60	22,232
				30,	.8400	.1320	11.30	2.1000	.0800	.65	26,000

Sewage in doses, each corresponding to 2,500 gallons per acre, applied 54 times a week until October 10; afterwards applied automatically about 112 times per week.
Surface raked about 1 inch deep each week.
Experiments interrupted by high water in the river April 13 to 18 and 20 to 22.
Effluent slightly turbid until October 6; afterwards turbid and with much sediment.

FILTER TANK NO. 15 A — *Concluded.*

WEEK ENDING —	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE. Sewage.	Effluent.	Date of Sample.	AMMONIA. Free.	Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Nov. 7,	23,000	-	48°	Nov. 3,	.5200	.1060	9.48	3.0500	.0400	.45	25,020
				7,	.4800	.0900	9.00	2.9200	.0040	.47	1,420
14,	21,086	-	51°	11,	.4000	.1340	8.22	2.8400	.0080	.54	14,300
				14,	.3800	.1140	8.57	3.4400	.0020	.57	3,400
21,	27,057	-	50°	17,	.6500	.3600	7.95	2.4100	.0500	1.79	39,000
				20,	1.0000	.1500	7.80	2.1600	.0140	.66	204,000
28,	40,943	-	50°	25,	.3200	.0720	7.60	3.0000	.0200	.43	24,000
				28,	.4700	.1300	7.07	2.9200	.0100	.61	20,600
Dec. 5,	35,143	-	46°	Dec. 2,	.6200	.1520	9.00	2.3000	.0100	.65	54,400
				5,	.6300	.1900	9.20	2.3300	.0040	1.04	205,000
12,	41,971	-	50°	9,	.5500	.1380	8.43	2.1800	.0140	.64	133,000
				12,	.5800	.1520	7.73	2.1000	.0060	.63	18,200
19,	47,000	-	46°	16,	.3500	.1660	7.76	2.1200	.0120	.82	42,000
				19,	.6300	.1800	7.98	1.3900	.0040	1.16	211,000
26,	45,029	-	49°	22,	.4800	.1300	7.27	1.7400	.0180	.75	35,000
				29,	.3700	.1360	7.28	2.1200	.0080	.77	98,700

Sewage in dose, each corresponding to 2,500 gallons per acre, applied automatically about 112 times per week.
Effluent slightly turbid and with considerable sediment.

Summary of Nineteen Microscopical Examinations of Effluent of Filter Tank No. 15 A.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ.			
Chlorococcus,	5	20	400
Ulothrix,	5	3	50
Fungi.			
Beggiatoa,	5	50	1,000
Molds,	16	11,000	205,000
Saccharomyces,	47	3,225	49,000
ANIMALS.			
Rhizopoda. Amœba,	5	10	200
Infusoria.			
Monas,	21	125	1,000
Paramæcium,	21	230	2,200
Vermes. Anguillula,	27	55	600

FILTER TANK No. 16 A.

This small tank five feet deep, filled with clean stones, the mechanical analysis of which was given on page 429, was described in the report upon the Purification of Sewage and Water, pages 563 and 670.

From November, 1889, to July 23, 1890, sewage was applied at the rate of 70,000 gallons per acre daily in small doses every hour for nine hours of the day. On July 24 the amount was increased to 108,000 gallons per acre daily, which was continued through November with uniformly good results. The filter appeared to do most of its work during the hours when sewage was applied, and it seemed quite probable that it was capable of doing as much additional work during the night as it was then doing in the day. To settle this point an automatic feed was arranged Nov. 29, 1890, which delivered sewage equivalent to 2,800 gallons per acre at intervals of from twenty to thirty minutes during days, nights and Sundays. The reservoir of sewage was replenished every morning and no other attention was required. Owing to imperfections in the apparatus employed the delivery was not absolutely regular, but afterwards improvements were made in the regulator, which insured good work. The quantity of sewage applied varied from 183,600 gallons per acre daily in February to 221,200 gallons in May. The results, although not so good as had been obtained during the previous year, with half the quantity applied in less than half the time, were still very satisfactory.

In the last week in July, however, nitrification and purification suddenly stopped. An excellent effluent was obtained July 24; on July 28 and 31 nitrification was checked, and August 1 it was entirely stopped. There was nothing visible to indicate the cause; the upper layers were not perceptibly dirtier than before. The surface was disturbed six inches deep on August 6, and left in ridges and furrows; and on August 19 it was again levelled. The sewage disappeared promptly, but there was no improvement in the effluent. From August 29 to September 8 no sewage was applied, but the rest was not beneficial. On September 14 the rate was reduced to

80,000 gallons per acre daily by increasing the intervals between the single doses, but without improvement.

An aspirator was attached to the bottom of the filter September 26 to 28, drawing a slow current of air through the filter from the top. This was removed after forty hours' operation, and sewage was again applied. The first sample following this had 2.75 parts per 100,000 of nitrates, and only one-third as much albuminoid ammonia as the previous samples; afterward the effluent rapidly returned to its previous condition. This experiment with the aspirator made it clear that the trouble with the filter was lack of fresh air. When the air was artificially changed there was at once an enormous improvement, followed by an immediate return to the old condition as soon as the new air was exhausted. It appeared that the method of applying sewage in small doses at short intervals did not cause sufficient movement in the air of the filter. When the stones were clean the air passed through them more freely, and sufficient ventilation was obtained. After two years' constant use the stones were slime-covered and the friction of the air was much greater, so that enough new air was no longer introduced.

On October 12 the size of the single doses was increased to 20,000 gallons per acre, but the filter received only eighteen doses per week, equivalent to 51,400 gallons per acre daily. It was hoped that this amount applied at one time would create a disturbance and change the air, and apparently it did so to a certain extent, for the nitrates increased somewhat, but incomparably less than they had done with the aspirator. To see if a still larger dose would be more effective, 40,000 gallons per acre were applied eighteen times a week, commencing November 1, and 80,000 gallons per acre six times a week, commencing November 13. This latter dose covered the surface and forced much old air out at the bottom. It was followed by largely increased nitrification, but the downward rush of so much sewage applied at one time rendered the effluent turbid, and the organic matter and bacteria remained very high, particularly in the first portion of the effluent after flooding.

On April 18, 1892, the dose was changed back to 20,000 gallons per acre of sewage applied twenty-four times a week, to see if, after five months of active nitrification, the filter had regained its powers; but low nitrates at once followed the change, showing that the condition of the filter had not improved.

On June 10, 1892, samples of the material from different depths were examined for organic matter with the following results: —

[Parts in 100,000, by weight.]

Depth.	Albuminoid Ammonia.	Nitrogen.	Depth.	Albuminoid Ammonia.	Nitrogen.
0 inches, . . .	8.0	13.2	24 inches, . . .	9.1	15.0
3 " . . .	12.9	21.2	36 " . . .	3.8	6.3
6 " . . .	16.0	26.4	48 " . . .	2.1	3.5
12 " . . .	11.0	18.1	60 " . . .	1.1	1.8
18 " . . .	9.2	15.1			

The work of this filter during the past two years is shown by the following table. In the first period of twelve months sewage was applied in nine hourly applications during the day-time at the rate first of 70,000 and then 108,000 gallons per acre daily, averaging for the year 92,800 gallons. In the second period of nine months sewage was applied in larger quantity, averaging 197,800 gallons per acre daily, the increased amount being applied in the night, the day applications remaining substantially as during the preceding period. The results up to this time were most satisfactory. In the last period of five months the effect of exclusion of air by the accumulation of organic matter is seen; the organic matters in the effluent are several times as high as during the earlier periods, the albuminoid ammonia being 24 per cent. of that of the sewage.

Average Results of Analyses of Sewage and Effluent of Filter Tank No. 16 A.

		Quantity Applied. Gallons per Acre Daily.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
November, 1889 — October, 1890,	Sewage, .	92,800	1.7800	.6400	5.47	0	0	3.11	951,000
	Effluent, .	-	.0752	.0409	6.15	1.49	.0011	.27	9,700
November, 1890 — July, 1891, .	Sewage, .	197,800	1.8200	.6700	6.41	0	0	3.19	674,000
	Effluent, .	-	.1558	.0408	6.19	1.12	.0016	.35	20,000
August — December, 1891, .	Sewage, .	94,000	2.7800	.8700	8.27	0	0	4.53	858,572
Insufficient ventilation, . .	Effluent, .	-	1.1987	.2084	7.89	.78	.0360	1.02	130,668

The weekly analyses are given in full in the following table: —

FILTER TANK NO. 16 A.

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
March 8, .	69,771	43°	40°	March 7, .	.0820	.0525	6.30	1.3000	.0024	.32	-
15, .	69,771	45°	44°	14, .	.6000	.1000	3.22	1.4000	.0022	.29	8,760
22, .	69,771	45°	43°	21, .	.1700	.0600	5.90	.9500	.0028	-	44,352
29, .	69,771	45°	43°	28, .	.0720	.0505	5.69	1.0500	.0024	.29	10,800
April 5, .	69,771	46°	46°	April 4, .	.1600	.0800	5.80	1.0500	.0050	.31	14,784
12, .	67,771	45°	45°	11, .	.0308	.0368	7.62	1.1000	.0022	.23	8,748
19, .	69,771	46°	49°	18, .	.0162	.0420	5.50	1.5000	.0006	.24	18,576
26, .	69,771	46°	50°	25, .	.0550	.0426	5.63	1.5000	.0014	.26	19,926
May 3, .	69,771	48°	52°	May 2, .	.1160	.0740	5.72	1.6000	.0014	.45	43,560
10, .	69,771	52°	56°	9, .	.0260	.0286	4.57	2.0000	.0006	.34	1,455
17, .	69,771	57°	60°	16, .	.0232	.0432	4.89	2.0000	.0026	.28	12,492
24, .	69,771	58°	60°	23, .	.0014	.0398	5.19	2.1000	.0002	.23	21,771
31, .	69,771	58°	59°	30, .	.0046	.0392	5.07	2.0000	.0002	.25	-
June 7, .	69,771	61°	60°	June 6, .	.0016	.0382	5.76	2.2500	.0004	.23	9,300
14, .	69,771	62°	61°	13, .	.0056	.0350	6.71	1.5000	.0000	.23	4,930
21, .	69,771	64°	67°	20, .	.0022	.0356	7.27	2.5000	.0002	.22	5,220
28, .	69,771	71°	69°	27, .	.0052	.0342	7.27	2.2500	.0002	.23	6,069
July 5, .	69,771	72°	71°	July 4, .	.0062	.0306	8.43	2.3500	.0006	.23	29,460
12, .	69,771	72°	69°	11, .	.0046	.0414	9.95	2.4000	.0004	.19	12,780
19, .	69,771	73°	71°	18, .	.0042	.0354	10.40	2.0000	.0002	.18	5,782
26, .	89,143	71°	67°	25, .	.0040	.0356	6.72	1.5000	.0002	.21	4,576
Aug. 2, .	108,514	73°	74°	Aug. 1, .	.0028	.0298	7.37	2.2500	.0002	.25	5,700
9, .	108,514	76°	73°	8, .	.0034	.0306	7.44	1.6000	.0002	.26	7,860
16, .	108,514	73°	70°	15, .	.0034	.0284	8.15	1.5000	.0000	.24	6,372
23, .	108,514	72°	70°	22, .	.0030	.0338	7.17	1.6500	.0002	.24	11,280
30, .	108,514	67°	68°	29, .	.0032	.0308	5.73	1.5000	.0000	.24	770
Sept. 6, .	107,229	66°	67°	Sept. 5, .	.0054	.0298	8.20	1.6500	.0006	.27	-
13, .	108,514	68°	68°	12, .	.0016	.0314	5.75	1.8300	.0006	.25	-
20, .	108,514	66°	68°	19, .	.0038	.0272	5.93	1.3500	.0000	.28	1,475
27, .	108,514	62°	61°	26, .	.0052	.0296	5.87	1.5000	.0000	.29	11,880
Oct. 4, .	108,514	60°	62°	Oct. 3, .	.0018	.0350	7.34	.8500	.0002	.36	27,360
11, .	108,514	59°	57°	10, .	.0120	.0354	6.07	1.5000	.0004	.35	3,600

Sewage applied 54 times a week till July 23, afterwards 84 times a week.
Effluent generally slightly turbid until July 25, afterwards clear or nearly so.

Filter Tank No. 16 A — *Continued*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
Oct. 18, .	108,514	54°	55°	Oct. 17, .	.0056	.0298	5.94	1.6500	.0004	.28	4,860
25, .	54,257	49°	49°	24, .	.0094	.0328	6.87	2.3500	.0004	.26	10,260
Nov. 1, .	108,514	47°	49°	31, .	.0252	.0356	5.56	1.1500	.0000	.38	14,986
8, .	107,229	45°	49°	Nov. 7, .	.0254	.0232	6.32	1.7600	.0004	.25	4,425
15, .	108,514	45°	47°	14, .	.0168	.0290	7.52	1.5500	.0006	.33	3,660
22, .	107,743	42°	45°	21, .	.1120	.0300	5.82	.8700	.0003	.32	11,880
29, .	122,114	40°	46°	29, .	.3500	.0440	5.75	1.2700	.0026	.28	6,300
Dec. 6, .	190,743	–	44°	Dec. 2, .	.4700	.0590	5.40	1.0600	.0012	.43	28,980
				5, .	.3850	.0400	4.84	1.1100	.0012	.35	1,500
13, .	203,800	–	46°	10, .	.6000	.0320	6.65	.8300	.0009	.34	15,300
				12, .	.2800	.0480	5.67	1.1700	.0010	.31	13,680
20, .	173,400	–	44°	16, .	.0600	.0340	3.82	.7500	.0014	.28	20,520
				19, .	.3500	.0320	15.00	1.0300	.0040	.30	18,360
27, .	177,543	–	44°	23, .	.1800	.0240	4.50	.9300	.0040	.28	10,800
				26, .	.2800	.0340	5.05	2.0200	.0035	.22	46,800
1891.											
Jan. 3, .	174,887	–	43°	30, .	.1500	.0300	3.64	1.2300	.0018	.25	70,560
10, .	169,714	–	44°	Jan. 6, .	.1800	.0320	4.07	1.0500	.0034	.26	24,840
				9, .	.1800	.0380	5.07	1.3700	.0045	.24	5,760
17, .	174,314	–	45°	13, .	.0900	.0240	4.27	1.8700	.0034	.25	19,800
				16, .	.1000	.0260	5.98	1.0300	.0050	.26	14,400
24, .	190,486	–	45°	20, .	.0740	.0300	4.60	2.4300	.0030	.23	22,500
				23, .	.0550	.0360	4.45	1.4000	.0030	.38	5,520
31, .	151,000	–	42°	27, .	.2200	.0552	3.69	1.3100	.0016	.49	15,300
				30, .	.2500	.0440	5.04	1.5100	.0040	.35	13,320
Feb. 7, .	184,143	–	42°	Feb. 3, .	.1400	.0420	4.47	1.4200	.0016	.38	12,000
				6, .	.4000	.0400	3.97	.6700	.0022	.44	66,600
14, .	189,429	–	42°	10, .	.7000	.0660	7.67	.8000	.0030	.57	69,120
				13, .	.1400	.0400	5.17	1.5200	.0036	.28	17,640
21, .	218,629	–	43°	17, .	.0380	.0388	4.07	.9700	.0014	.46	12,960
				20, .	.1300	.0260	3.40	.6300	.0016	.37	3,480
28, .	150,457	–	45°	24, .	.1460	.0360	6.20	1.1100	.0036	.34	2,160

Sewage applied 84 times a week till November 28, when the automatic feed was attached, and the number of applications was increased to about 500 per week.

Surface raked about one inch deep each week, beginning December 18.

Experiments interrupted by high water in the river October 20-22, January 25, 26, February 27, March 1, 12-16, 23-29.

Effluent clear until November 14 and afterwards generally slightly turbid.

FILTER TANK NO. 16 A — *Continued*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
March 7, .	195,400	-	40°	March 3, .	.0880	.0344	4.16	1.0400	.0016	.32	5,820
				6, .	.0840	.0308	3.95	1.1300	.0016	.26	3,900
14, .	110,429	-	44°	10, .	.0120	.0340	4.70	1.1900	.0007	.31	4,500
21, .	156,686	-	41°	20, .	.0540	.0300	3.92	1.3000	.0008	.31	10,800
28, .	28,029	-	-	-	-	-	-	-	-	-	-
April 4, .	190,229	-	44°	31, .	.2600	.0520	7.48	1.0700	.0036	.35	12,960
				April 3, .	.1800	.0420	4.80	.9500	.0016	.29	9,000
11, .	231,286	-	44°	7, .	.1040	.0260	4.12	.8400	.0012	.25	8,100
				10, .	.0240	.0300	4.82	.9800	.0006	.17	3,600
18, .	46,600	-	-	-	-	-	-	-	-	-	-
25, .	126,514	-	53°	24, .	.0076	.0326	4.50	2.8400	.0000	.23	37,400
May 2, .	218,943	-	52°	28, .	.0160	.0306	5.50	1.2200	.0000	.27	45,360
				May 1, .	.0126	.0402	5.48	.7800	.0004	.32	52,320
9, .	213,914	-	50°	5, .	.0108	.0368	7.00	.7000	.0008	.31	90,000
				8, .	.0092	.0386	6.97	.6000	.0001	.36	2,460
16, .	226,857	-	56°	12, .	.0460	.0484	5.24	.6100	.0006	.33	36,000
				15, .	.0468	.0464	6.94	.6300	.0002	.32	22,500
23, .	222,829	-	58°	19, .	.1700	.0520	13.80	.5300	.0012	.36	27,000
				22, .	.2300	.0540	7.78	.2100	.0008	.54	28,600
30, .	221,629	-	59°	26, .	.6500	.1100	5.30	.0100	.0000	.83	108,000
				29, .	.8800	.1280	5.80	.0300	.0040	.86	43,200
June 6, .	231,314	-	61°	June 2, .	.6400	.0920	6.52	.5800	.0060	.63	97,200
				5, .	.0740	.0520	6.76	1.3500	.0016	.42	12,204
13, .	228,971	-	66°	9, .	.0220	.0520	5.68	2.6200	.0004	.39	30,240
				12, .	.0048	.0456	10.36	1.4100	.0002	.39	1,680
20, .	228,029	-	65°	16, .	.0022	.0334	8.45	1.2300	.0007	.38	1,080
				19, .	.0020	.0350	10.53	.7900	.0000	.40	340
27, .	229,171	-	67°	23, .	.0022	.0366	6.26	1.2700	.0000	.34	132
				26, .	.0270	.0476	10.82	.8600	.0004	.40	4,340
July 4, .	226,086	-	66°	30, .	.1200	.0540	9.90	.7800	.0030	.46	2,900
				July 3, .	.0156	.0168	8.00	1.0400	.0008	.30	3,780
11, .	222,486	-	67°	7, .	.1800	.0640	11.43	1.1700	.0024	.39	1,420
				10, .	.0210	.0370	9.31	1.0400	.0000	.29	2,620

Sewage applied about 500 times per week.
Surface raked about 1 inch deep each week.
Experiments interrupted by high water in the river April 13-17 and 20, 21.
Effluent generally slightly turbid.

FILTER TANK NO 16 A — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
July 18, .	219,343	-	73°	July 14, .	.0164	.0416	8.40	.9100	.0001	.37	7,200
				17, .	.0176	.0416	5.49	1.1200	.0000	.34	-
25, .	220,286	-	70°	21, .	.0208	.0458	8.98	1.2300	.0004	.31	19,800
				24, .	.0092	.0454	9.90	1.0500	.0002	.27	16,780
Aug. 1, .	220,200	-	67°	28, .	.3700	.0400	8.22	.3100	.0024	.46	37,350
				31, .	.5400	.1200	8.10	.2700	.0030	.72	54,540
8, .	207,571	-	70°	Aug. 4, .	2.0000	.2540	6.30	.0100	.0000	1.60	110,000
				7, .	1.6000	.3000	6.80	.0000	.0000	1.56	9,340
15, .	223,143	-	74°	11, .	2.2500	.3900	7.20	.0000	.0000	1.72	22,500
				14, .	2.1500	.3800	7.66	.0000	.0000	2.00	832
22, .	212,057	-	71°	18, .	2.4000	.3700	7.03	.0000	.0000	2.10	500,000
				21, .	2.7500	.2400	7.55	.0000	.0000	1.60	84,960
29, .	180,543	-	73°	25, .	2.5000	.3200	7.98	.0000	.0010	1.80	201,000
				28, .	.4500	.0500	8.16	.0300	.0002	1.10	164,000
Sept. 5, .	0	-	-	-	-	-	-	-	-	-	-
12, .	101,914	-	65°	Sept. 11, .	1.3000	.2900	7.18	.0000	.0000	.80	124,200
19, .	98,114	-	68°	15, .	1.6500	.3800	6.31	.0000	.0000	1.10	87,120
				18, .	1.3500	.3300	6.60	.0000	.0008	1.20	41,760
26, .	61,200	-	70°	22, .	1.8500	.2600	7.30	.0000	.0004	.90	73,880
				25, .	1.6500	.3300	9.23	.0000	.0020	.80	90,316
Oct. 3, .	58,343	-	66°	29, .	1.0400	.1100	14.57	2.7500	.1000	.53	15,570
				Oct. 2, .	1.1000	.1400	12.72	1.2900	.0110	.44	11,860
10, .	60,543	-	61°	6, .	.9600	.1320	11.28	.3600	.0040	.72	99,900
				9, .	1.6000	.1420	9.96	.1100	.0100	.80	43,000
17, .	51,429	-	55°	13, .	1.8000	.1380	10.42	.3600	.0120	.56	20,700
				16, .	1.3000	.1120	8.35	.4500	.0036	.50	22,500
24, .	51,429	-	53°	20, .	1.3000	.1180	7.85	.4500	.0024	.54	27,360
				23, .	1.2600	.0900	7.35	.4800	.0040	.47	14,070
31, .	48,571	-	50°	27, .	1.2000	.1380	10.96	.6500	.0036	.46	26,577
				30, .	1.3000	.0720	11.00	.6700	.0018	.46	38,000
Nov. 7, .	102,857	-	46°	Nov. 3, .	1.0400	.1300	7.65	.4000	.3000	.81	51,480
				6, .	.6400	.1200	6.75	.4300	.0200	.72	166,000

Sewage applied about 500 times per week until August 29; about 200 times September 8 to October 11; 18 times October 12 to 31, and afterwards 6 times.

Surface raked about 1 inch deep each week; spaded 6 inches deep August 6.

Air drawn through tank by an aspirator September 26-28.

Effluent slightly turbid July 14-21; afterwards very turbid.

FILTER TANK NO. 16 A — *Concluded.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Nov. 14,	97,143	-	51°	Nov. 10,	.7000	.1260	7.15	.0300	.0000	.73	53,000
				13,	1.2000	.1660	9.00	.4400	.0000	.93	118,000
21,	68,571	-	49°	17,	.9500	.2500	6.75	.8900	.1800	1.34	232,000
				20,	.8400	.2560	7.40	1.8200	.0400	1.42	175,000
28,	68,571	-	49°	24,	.4000	.1740	6.37	2.6800	.0800	.78	338,333
				27,	.5600	.3100	6.10	2.4900	.0400	1.46	228,000
Dec. 5,	68,571	-	47°	Dec. 2,	.5000	.2160	7.47	1.9600	.0600	1.93	80,000
				4,	.4200	.1560	7.30	1.7800	.0800	.90	342,000
12,	68,571	-	48°	8,	.3300	.1440	7.18	2.0200	.1200	.74	518,000
				11,	.1800	.0860	6.33	2.1400	.0100	.57	200,000
19,	68,571	-	45°	15,	.3200	.1400	7.20	2.0700	.2200	.72	391,000
				18,	.2800	.1060	8.23	1.8700	.0150	1.04	159,000
26,	68,571	-	49°	22,	.3700	.1180	6.72	2.0300	.0160	.51	36,000
				29,	.3500	.1160	6.98	2.1000	.1300	.70	127,000

Sewage applied 6 times a week.
Surface raked about 1 inch deep each week.
Effluent turbid and with much sediment.

Summary of Thirty-four Microscopical Examinations of Effluent of Filter Tank No. 16 A.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Navicula,	3	0.8	25
Nitzchia,	3	1.5	50
Algæ.			
Palmella,	3	180.	6,100
Ulothrix,	3	1.5	50
Fungi.			
Crenothrix,	3	15.	475
Spirillum,	3	0.8	25
Saccharomyces,	42	1,175.	14,800
ANIMALS.			
Infusoria.			
Monas,	66	2,160.	26,000
Paramæcium,	36	530.	800
Trachelomonas,	3	3.	100
Vorticella,	6	9.	200
Vermes.			
Anguillula,	18	23.	600
Rotifer,	3	0.8	25
Rotatorian ova,	9	12.	200

FILTER TANK No. 17 A.

This small tank of No. 9 sand, having the mechanical analysis given on page 429, and midway in size between No. 1 and No. 2 sands, and containing layers of marble dust, was described in the report upon the Purification of Sewage and Water, page 687.

Commencing Jan. 28, 1890, sewage was applied at the rate of 25,700 gallons per acre daily, and February 19 the dose was increased to 51,400 gallons. The history of this filter was the same as that of other tanks started during cold weather; at first there was oxidation to ammonia and carbonic acid, with storage of a part of the organic matter, followed in April by nitrification, which became practically complete in May.

Commencing Oct. 27, 1890, sulphuric acid was added to the applied sewage, equivalent to 49 parts actual acid in 100,000. This temporarily checked nitrification, but the effluent quickly returned to its former condition and has continued to be in every way satisfactorily purified throughout the year up to Jan. 1, 1892.

We have thus obtained complete nitrification and purification with acid sewage by using a filter containing layers of marble, which neutralize the acid, and allow the processes of purification to take place as freely as with an ordinary sewage filtered through sand alone. The practical importance of this experiment is very great. If it should ever be found that a filter was giving imperfect results owing to the continued application of acid sewage, the addition of a little marble or limestone to the upper layer of the filter could be depended upon to neutralize the acid and insure as good results as could otherwise be obtained with normal sewage.

A striking point in connection with this filter is the low number of bacteria. For the year 1891 the average number in the effluent was only four, and in a majority of all the determinations made none were found. It seems most probable that most if not all of the few bacteria found were due to accidental contamination, and that the effluent would otherwise have been uniformly sterile. This cannot be due to the mechanical effect of the marble dust, for during the first nine months, when this filter and No. 19, its exact counterpart with the exception of the marble, were receiving the same treatment

with ordinary sewage, the results obtained were almost identical in the two cases, and the number of bacteria in No. 17 A was much higher than when acid was applied.

It seems probable that the low numbers since the application of acid are due to the sterilizing effect of the acid at the top of the filter before it becomes neutralized by the marble. The acid kills a very large proportion of the sewage bacteria, and the filter appears to be able to retain all of those which resist the acid.

The work of this filter for two years can be divided into three periods: before complete nitrification, during nitrification with normal sewage, and last with strongly acid sewage. The average results for these periods are as follows: —

Average Results of Analyses of Sewage and Effluent of Filter Tank No. 17 A.

		Quantity Applied. — Gallons per Acre Daily.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
February — April, 1890,	Sewage,	45,400	1.4700	.7000	4.55	0	0	3.19	528,000
Before high nitrification,	Effluent,	-	.5257	.0317	5.16	.33	.0064	.13	965
May — October, 1890,	Sewage,	50,400	2.0500	.6500	6.06	0	0	3.08	1,415,000
Normal sewage,	Effluent,	-	.0038	.0131	5.86	2.07	.0010	.10	68
November, 1890 — December, 1891,	Sewage,	51,800	2.1600	.7400	7.08	0	0	3.67	739,700
Acid sewage,	Effluent,	-	.0181	.0150	6.48	2.34	.0068	.17	4

The full weekly results are shown in the following table: —

FILTER TANK NO. 17 A.

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed	Bacteria per Cubic Centimeter.
1890.												
Feb. 1,	25,714	40°	40°	-	Jan. 28,	.0170	.0062	.52	.0100	.0004	-	-
					30,	.0136	.0074	1.72	.0100	.0000	-	-
8,	25,714	45°	43°	-	Feb. 4,	.0220	.0095	13.80	.0100	.0001	-	-
					7,	.0142	.0116	9.85	.0100	.0000	-	-

First sewage applied January 28.

FILTER TANK No. 17 A — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Feb. 15,	25,714	44°	44°	-	Feb. 11,	.0198	.0134	5.32	.0200	.0002	-	-
					14,	.0140	.0120	5.17	.0200	.0000	-	-
22,	42,857	45°	39°	-	19,	.0164	.0118	3.94	.0200	.0000	-	-
					21,	.0098	.0142	5.42	.0200	.0000	-	-
March 1,	51,429	45°	44°	-	25,	.0068	.0164	4.94	.0100	.0002	-	-
					28,	.0316	.0244	4.37	.0100	.0002	-	-
8,	51,429	43°	40°	-	March 4,	.1225	.0175	4.35	.0100	.0002	.16	-
					7,	.3080	.0310	4.12	.0100	.0002	.16	-
15,	51,429	45°	44°	-	11,	.6300	.0300	6.05	.0100	.0004	.13	360
					14,	1.0000	.0600	5.09	.0100	.0006	.18	-
22,	51,429	45°	43°	-	18,	1.1000	.0500	2.98	.0200	.0010	.15	-
					21,	1.0000	.0400	3.00	.0300	.0008	-	-
29,	51,429	45°	43°	-	25,	1.1000	.0400	4.10	.0300	.0012	.13	-
April 5,	51,429	45°	46°	-	April 1,	1.2000	.0500	4.67	.0500	.0070	.13	29
12,	51,429	45°	46°	-	8,	1.1000	.0300	4.70	.1400	.0180	.12	42
19,	51,429	45°	50°	-	15,	1.0500	.0700	5.62	.3600	.0220	.12	218
26,	51,429	46°	50°	-	22,	.6500	.0500	4.32	1.8000	.0300	.14	92
May 3,	51,429	48°	52°	-	29,	.0440	.0160	3.88	2.5000	.0150	.11	-
10,	51,429	52°	56°	-	May 6,	.0096	.0158	5.02	2.5000	.0024	.13	55
17,	51,429	56°	60°	-	13,	.0052	.0168	4.27	2.2500	.0014	.10	1
24,	51,429	58°	59°	-	20,	.0040	.0148	4.55	2.5000	.0022	.10	49
31,	51,429	57°	58°	-	27,	.0030	.0140	5.14	2.5000	.0022	.10	-
June 7,	51,429	61°	59°	-	June 3,	.0032	.0138	4.87	1.8000	.0014	.08	15
14,	51,429	62°	61°	-	10,	.0024	.0138	5.42	2.1000	.0016	.13	12
21,	51,429	66°	64°	-	17,	.0044	.0154	4.99	2.0000	.0018	.09	2
28,	51,429	71°	67°	-	24,	.0038	.0152	6.12	2.5000	.0020	.09	47
July 5,	51,429	72°	70°	-	July 1,	.0024	.0158	5.50	1.9000	.0022	.10	10
12,	51,429	72°	70°	-	8,	.0034	.0108	6.38	2.2500	.0008	.07	4
19,	51,429	73°	70°	-	15,	.0022	.0112	5.53	2.5000	.0010	.09	3
26,	51,429	70°	66°	-	22,	.0018	.0134	6.05	2.5000	.0010	.09	0
Aug. 2,	51,429	73°	73°	-	29,	.0024	.0104	5.30	2.1500	.0006	.09	12
9,	51,429	76°	73°	-	Aug. 5,	.0024	.0126	5.53	1.7500	.0006	.11	1
16,	51,429	73°	68°	-	12,	.0020	.0138	6.20	2.5000	.0006	.09	6

Sewage applied 6 times a week.
June 7, surface raked about 2 inches deep.
Effluent clear and colorless.

FILTER TANK NO. 17 A — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Aug. 23,	51,429	72°	69°	-	Aug. 19,	.0012	.0120	11.48	1.9000	.0002	.10	35
30,	51,429	67°	67°	-	26,	.0022	.0186	10.05	2.0000	.0006	.11	17
Sept. 6,	51,429	66°	66°	-	Sept. 2,	.0024	.0128	7.70	2.0000	.0006	.06	-
13,	51,429	68°	67°	-	9,	.0022	.0122	4.90	2.0000	.0006	.10	-
20,	51,429	66°	67°	-	16,	.0014	.0116	4.98	1.5500	.0000	.10	117
27,	51,429	62°	61°	-	23,	.0020	.0196	5.06	1.7500	.0000	.07	7
Oct. 4,	51,429	60°	60°	-	30,	.0008	.0098	4.97	1.6000	.0000	-	9
11,	51,429	59°	56°	-	Oct. 7,	.0008	.0104	6.24	1.9000	.0000	.10	28
18,	48,571	54°	54°	-	14,	.0008	.0080	4.90	1.4000	.0000	.08	16
25,	25,714	49°	48°	-	25,	.0008	.0104	5.02	1.2500	.0002	.11	61
Nov. 1,	51,429	47°	48°	-	28,	.0072	.0090	4.94	2.2500	.0016	.11	1,020
					31,	.0300	.0120	6.32	2.3000	.0008	.15	349
8,	51,429	45°	48°	-	Nov. 4,	.0244	.0188	5.44	1.5400	.0014	.22	17
					7,	.0740	.0240	5.41	1.5800	.0450	.25	8
15,	51,429	45°	46°	-	11,	.0840	.0380	5.01	1.9300	.0600	.28	5
					14,	.1350	.0340	5.34	1.8900	.0600	.25	2
22,	51,429	42°	45°	-	18,	.1680	.0380	5.82	1.8100	.1100	.25	0
29,	51,429	40°	44°	-	25,	.0640	.0160	5.30	1.9600	.0450	.19	1
Dec. 6,	51,429	45°	43°	-	Dec. 2,	.0420	.0156	5.37	1.7000	.0400	.21	0
13,	51,429	45°	45°	-	9,	.0256	.0146	5.77	1.6300	.0280	.20	1
20,	51,429	45°	43°	-	16,	.0090	.0124	6.44	1.4800	.0080	.14	610
27,	51,429	45°	44°	-	23,	.0042	.0168	13.17	1.4000	.0025	.18	2
1891.												
Jan. 3,	51,429	45°	43°	-	30,	.0022	.0134	5.27	1.2600	.0036	.16	1
10,	51,429	45°	43°	-	Jan. 6,	.0018	.0162	3.84	1.3800	.0032	.17	24
17,	51,429	46°	43°	-	13,	.0040	.0122	5.13	1.2500	.0012	.16	4
24,	51,429	45°	44°	-	20,	.0020	.0104	3.20	.9600	.0004	.10	4
31,	42,857	44°	40°	-	27,	.0042	.0112	4.54	1.2900	.0009	.16	0
Feb. 7,	51,429	44°	41°	-	Feb. 3,	.0024	.0142	4.32	1.3500	.0004	.14	0
14,	51,429	44°	41°	-	10,	.0056	.0130	3.90	1.0900	.0016	.14	0
21,	51,429	44°	42°	-	17,	.0408	.0124	5.32	1.3900	.0045	.18	0

Sewage applied 6 times a week. Commencing October 27, 49 parts per 100,000 of sulphuric acid were added to the sewage.

Surface raked about 1 inch deep each week commencing October 18.

Experiments interrupted by high water in the river October 20-22, January 24-26.

Effluent clear and colorless.

FILTER TANK NO. 17 A — *Continued.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
Feb. 28,	34,286	44°	44°	-	Feb. 24,	.0106	.0132	3.50	.9400	.0012	.16	1
March 7,	51,429	44°	39°	-	March 3,	.0120	.0120	4.70	1.1100	.0012	.21	0
14,	25,714	45°	43°	-	10,	.0348	.0134	3.82	.9200	.0012	.16	1
21,	42,857	44°	39°	-	-	-	-	-	-	-	-	-
28,	0	-	-	-	-	-	-	-	-	-	-	-
April 4,	51,429	45°	43°	-	31,	.0500	.0142	3.52	1.6700	.0032	.13	2
11,	51,429	44°	42°	-	April 7,	.0346	.0124	5.27	1.7700	.0032	.15	45
18,	0	-	-	-	-	-	-	-	-	-	-	-
25,	34,286	52°	51°	-	-	-	-	-	-	-	-	-
May 2,	51,429	50°	50°	-	28,	.1308	.0224	5.18	3.3000	.0060	.22	15
9,	51,429	50°	50°	-	May 5,	.0040	.0132	4.70	2.3500	.0012	.16	10
16,	51,429	56°	54°	-	12,	.0028	.0140	6.60	2.2000	.0010	.13	2
23,	51,429	55°	56°	-	19,	.0006	.0130	4.42	2.5800	.0006	.17	2
30,	51,429	60°	58°	-	26,	.0004	.0156	4.43	2.4900	.0000	.18	3
June 6,	51,429	63°	60°	-	June 2,	.0014	.0142	4.27	3.4300	.0000	.18	5
13,	51,429	64°	65°	-	9,	.0014	.0150	4.78	4.6200	.0000	.18	0
20,	51,429	70°	65°	-	16,	.0012	.0146	12.24	4.6200	.0012	.19	24
27,	51,429	67°	65°	-	23,	.0002	.0154	9.50	3.6500	.0000	.16	0
July 4,	51,429	64°	66°	-	30,	.0006	.0136	7.26	2.9900	.0000	.21	0
11,	51,429	67°	66°	-	July 7,	.0006	.0144	6.58	3.3000	.0002	.18	-
18,	51,429	73°	71°	-	14,	.0012	.0146	7.80	2.9200	.0000	.19	10
25,	51,429	73°	69°	-	21,	.0002	.0140	7.22	3.5200	.0000	.18	0
Aug. 1,	51,429	70°	67°	-	28,	.0008	.0150	11.64	3.3900	.0001	.18	0
8,	51,429	70°	69°	-	Aug. 4,	.0006	.0142	11.82	2.7700	.0000	.14	0
15,	51,429	74°	73°	-	11,	.0004	.0148	7.22	2.9500	.0000	.13	1
22,	51,429	73°	72°	-	18,	.0012	.0160	7.20	3.5100	.0001	.17	0
29,	51,429	73°	72°	-	25,	.0010	.0144	7.75	3.3000	.0001	.14	7
Sept. 5,	51,429	67°	66°	-	Sept. 1,	.0016	.0140	7.97	3.0800	.0005	.14	0
12,	51,429	65°	64°	-	8,	.0004	.0116	8.67	2.5500	.0000	.14	12
19,	51,429	67°	66°	-	15,	.0008	.0124	7.15	1.8900	.0000	.12	2
26,	51,429	69°	69°	-	22,	.0008	.0114	6.48	3.0800	.0000	.13	16
Oct. 3,	51,429	69°	66°	-	29,	.0010	.0162	14.37	3.4300	.0000	.16	3

Sewage, to which 49 parts per 100,000 of sulphuric acid was added, applied 6 times a week.

Surface raked about 3 inches deep each week, commencing February 26.

Experiments interrupted by high water in the river February 27 to March 1, March 12-16, 23 29, April 13-18, 20-22.

Effluent clear and colorless.

FILTER TANK NO. 17 A — *Concluded.*

Week Ending —	Quantity Applied — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
Oct. 10,	51,429	65°	60°	-	Oct. 6,	.0006	.0156	8.05	3.8600	.0002	.14	0
17,	51,429	56°	54°	-	13,	.0034	.0120	9.27	2.9900	.0000	.16	0
24,	51,429	51°	56°	-	20,	.0014	.0138	5.50	2.7300	.0000	.13	0
31,	51,429	46°	48°	-	27,	.0002	.0116	5.48	2.4800	.0002	.17	1
Nov. 7,	51,429	45°	45°	-	Nov. 3,	.0036	.0130	8.15	2.7000	.0460	.15	0
14,	51,429	45°	51°	-	10,	.0040	.0124	6.52	2.2900	.0016	.15	0
21,	51,429	46°	49°	-	17,	.0006	.0144	8.03	2.6400	.0000	.16	0
28,	51,429	43°	48°	-	24,	.0018	.0138	7.22	2.7300	.0007	.16	0
Dec. 5,	51,429	40°	46°	1h. 30m.	Dec 1,	.0006	.0124	6.11	2.5500	.0002	.18	0
12,	51,429	44°	47°	32m.	8,	.0104	.0148	8.53	2.4800	.0110	.20	0
19,	51,429	45°	44°	39m.	15,	.0012	.0126	6.55	2.0700	.0016	.16	0
26,	51,429	45°	47°	-	22,	.0006	.0138	8.37	2.1100	.0002	.13	0
					29,	.0012	.0108	8.10	1.9100	.0001	.17	0

Sewage, to which 49 parts per 100,000 of sulphuric acid was added, applied 6 times a week.
Surface raked about 3 inches deep each week.
Effluent clear and colorless.

Summary of Twenty Microscopical Examinations of Effluent of Filter Tank No 17 A.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Fungi. Molds, ...	5	1.2	25
ANIMALS.			
Infusoria. Monas, ...	5	1.2	25

FILTER TANK No. 19.

This small tank is exactly like No. 17 A except the layers of marble dust, which were omitted. During the first nine months, from February to October, 1890, the treatment of and results from the two tanks were in every way similar. Afterwards No. 17 A was used for acid sewage, while the quantity of sewage on No. 19 was increased October 27, 1890, from 51,400 to 103,000 gallons per acre daily. This was followed by a temporary increase in the ammonias, but the filter rapidly recovered and continued doing excellent work with this very large quantity up to November 1, 1891. The free ammonia and nitrites were then slowly increasing, probably indicating a deficiency of air, and the dose was reduced to 51,400 gallons per acre daily, the amount No. 17 A had uniformly received. Following this reduction in quantity the ammonias slowly decreased during the remainder of the year. The work of this filter may be divided into three periods, corresponding to those for No. 17 A, during which the average results were as follows: —

Average Results of Analyses of Sewage and Effluent of Filter Tank No. 19.

		Quantity Applied. Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
February—April, 1890,	Sewage,	44,600	1.4739	.7021	4.55	0	0	3.19	528,000
Before high nitrification,	Effluent,	-	.4473	.0295	4.25	.49	.0102	.12	259
May—October, 1890,	Sewage,	51,400	2.0545	.6500	6.06	0	0	3.08	1,415,000
Nitrification,	Effluent,	-	.0077	.0111	5.82	2.21	.0028	.09	763
November, 1890—December, 1891,	Sewage,	94,400	2.1600	.7400	7.08	0	0	3.67	740,000
Increased quantity,	Effluent,	-	.0231	.0157	6.92	2.07	.0047	.16	307

The weekly results are given in full in the following table: —

FILTER TANK NO. 19.

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Feb. 1,	25,000	40°	41°	-	Jan. 28,	.0102	.0064	.20	.0100	.0004	-	-
					30,	.0066	.0024	.17	.0200	.0001	-	-
8,	25,714	45°	43°	-	Feb. 4,	.0064	.0048	.20	.0100	.0002	-	-
					7,	.0106	.0086	2.32	.0100	.0001	-	-
15,	25,714	44°	44°	-	11,	.0160	.0104	4.07	.0200	.0004	-	-
					14,	.0154	.0082	4.39	.0400	.0004	-	-
22,	42,857	45°	40°	-	19,	.0156	.0096	4.09	.0400	.0006	-	-
					21,	.0182	.0130	5.82	.0300	.0004	-	-
March 1,	51,429	45°	43°	-	25,	.0854	.0170	5.55	.0200	.0004	-	-
					28,	.2760	.0420	4.22	.0300	.0008	-	-
8,	51,429	43°	40°	-	March 4,	.2900	.0380	3.95	.0300	.0012	.15	245
					7,	.3820	.0420	4.34	.0400	.0008	.17	55
15,	51,429	45°	44°	-	11,	.8500	.0600	6.44	.0300	.0016	.14	2
					14,	.7200	.0400	5.02	.0400	.0018	.13	561
22,	51,429	45°	44°	-	18,	.7500	.0400	3.27	.0700	.0032	.12	112
					21,	.7500	.0300	3.04	.1100	.0024	-	750
29,	51,429	45°	43°	-	25,	1.0500	.0400	4.14	.1500	.0022	.13	13
April 5,	51,429	46°	46°	-	April 1,	1.0500	.0300	4.72	.2500	.0020	.12	85
12,	51,429	45°	45°	-	8,	1.0000	.0300	4.97	.6000	.0340	.12	59
19,	51,429	46°	49°	-	15,	.7800	.0400	6.79	1.2000	.0400	.12	162
26,	51,429	46°	50°	-	22,	.1700	.0500	4.64	2.3000	.0450	.12	138
May 3,	51,429	48°	52°	-	29,	.0360	.0220	3.89	2.6000	.0200	.08	-
10,	51,429	52°	56°	-	May 6,	.0070	.0098	5.00	2.5000	.0100	.12	53
17,	51,429	56°	59°	-	13,	.0048	.0136	4.37	2.5000	.0060	.08	0
24,	51,429	58°	60°	-	20,	.0054	.0106	4.55	2.5000	.0070	.08	10
31,	51,429	58°	59°	-	27,	.0060	.0106	5.04	2.5000	.0050	.09	43
June 7,	51,429	61°	61°	-	June 3,	.0046	.0102	4.65	1.8000	.0036	.09	3
14,	51,429	62°	61°	-	10,	.0056	.0120	5.40	2.0000	.0028	.10	1
21,	51,429	64°	67°	-	17,	.0088	.0132	4.96	2.0000	.0030	.08	4
28,	51,429	71°	68°	-	24,	.0076	.0104	6.12	2.5000	.0025	.08	53
July 5,	51,429	72°	70°	-	July 1,	.0066	.0118	5.82	2.6000	.0040	.08	4

Sewage applied 6 times a week, beginning January 28.
Effluent clear and colorless.

FILTER TANK NO. 19 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
July 12,	51,429	72°	71°	-	July 8,	.0078	.0105	6.22	2.4000	.0060	.07	28
19,	51,429	73°	70°	-	15,	.0058	.0100	5.56	2.5000	.0024	.08	1
26,	51,429	71°	66°	-	22,	.0058	.0098	5.97	2.5000	.0030	.07	0
Aug. 2,	51,429	73°	72°	-	29,	.0060	.0118	5.22	2.2500	.0026	.07	1
9,	51,429	76°	73°	-	Aug. 5,	.0068	.0126	5.72	2.2500	.0024	.11	106
16,	51,429	73°	69°	-	12,	.0074	.0100	6.18	2.7500	.0022	.07	78
23,	51,429	72°	69°	-	19,	.0072	.0092	12.02	2.4000	.0018	.13	84
30,	51,429	67°	67°	-	26,	.0072	.0116	10.50	2.3500	.0024	.09	7
Sept. 6,	51,429	66°	66°	-	Sept. 2,	.0058	.0104	7.78	2.2500	.0012	.07	1
13,	51,429	68°	67°	-	9,	.0076	.0124	7.07	1.9000	.0014	.07	-
20,	51,429	64°	67°	-	16,	.0036	.0110	4.82	1.8500	.0004	.11	33
27,	51,429	62°	61°	-	23,	.0046	.0086	5.21	2.2500	.0004	.08	8
Oct. 4,	51,429	60°	60°	-	30,	.0034	.0096	5.02	1.8500	.0002	-	19
11,	51,429	59°	56°	-	Oct. 7,	.0032	.0108	2.27	2.4000	.0010	.10	14
18,	51,429	54°	54°	-	14,	.0024	.0102	5.02	1.7500	.0006	.10	43
25,	25,714	49°	48°	-	25,	.0008	.0124	4.72	1.9000	.0004	.11	91
Nov. 1,	102,857	47°	47°	-	28,	.0014	.0112	5.47	2.0000	.0004	.11	188
					31,	.0698	.0166	5.44	.9000	.0016	.17	21,771
8,	102,857	45°	48°	-	Nov. 4,	.1050	.0164	5.77	1.4600	.0022	.19	8,550
					7,	.1600	.0200	4.91	2.2000	.0050	.14	314
15,	102,857	45°	46°	-	11,	.1800	.0300	5.21	1.7600	.1000	.17	1,180
					14,	.1090	.0280	5.22	1.0000	.0024	.19	810
22,	102,857	42°	45°	-	18,	.1700	.0320	5.57	2.1400	.0026	.18	780
29,	102,857	40°	44°	-	25,	.0120	.0116	6.30	1.9700	.0016	.18	320
Dec. 6,	102,857	45°	43°	-	Dec. 2,	.0064	.0140	5.82	2.1900	.0024	.16	1,080
13,	102,857	45°	44°	-	9,	.0042	.0110	4.22	1.4100	.0008	.13	540
20,	102,857	45°	43°	-	16,	.0038	.0106	5.80	1.7300	.0014	.10	124
27,	102,857	45°	43°	-	23,	.0022	.0090	3.67	1.5000	.0006	.10	720
1891.												
Jan. 3,	102,857	45°	42°	-	30,	.0022	.0076	3.32	.9600	.0002	.11	152
10,	102,857	45°	42°	-	Jan. 6,	.0034	.0108	3.56	1.3800	.0011	.12	28

Sewage applied 6 times a week.
Surface raked about 1 inch deep each week commencing October 18.
Experiments interrupted by high water in the river October 20–22.
Effluent clear and colorless.

FILTER TANK NO. 19 — *Continued.*

WEEK ENDING —	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE.		Sewage remained on Surface.	Date of Sample.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.												
Jan. 17,	102,857	46°	43°	-	Jan. 13,	.0030	.0088	2.81	1.2600	.0000	.08	112
24,	102,857	45°	43°	-	20,	.0034	.0098	3.32	1.8500	.0006	.10	48
31,	85,714	44°	40°	-	27,	.0072	.0144	6.50	.9100	.0024	.15	4,820
Feb. 7,	102,857	44°	41°	-	Feb. 3,	.0058	.0130	4.42	1.6200	.0012	.15	64
14,	102,857	44°	41°	-	10,	.0040	.0122	5.09	1.5800	.0012	.12	4
21,	102,857	44°	42°	-	17,	.0050	.0134	5.62	1.0500	.0028	.13	46
28,	68,571	44°	43°	-	24,	.0040	.0114	4.82	1.0900	.0000	.10	10
March 7,	102,857	44°	39°	-	March 3,	.0034	.0122	1.90	1.0300	.0006	.12	30
14,	51,429	45°	43°	-	10,	.0072	.0120	4.17	1.1400	.0016	.12	30
21,	85,714	44°	39°	-	-	-	-	-	-	-	-	-
28,	0	-	-	-	-	-	-	-	-	-	-	-
April 4,	102,857	45°	42°	-	31,	.0124	.0108	4.02	1.6200	.0016	.12	3
11,	102,857	44°	42°	-	April 7,	.0164	.0110	3.78	1.3400	.0016	.10	110
18,	0	-	-	-	-	-	-	-	-	-	-	-
25,	68,571	52°	51°	-	-	-	-	-	-	-	-	-
May 2,	102,857	50°	50°	-	28,	.0096	.0156	5.18	3.3000	.0060	.22	15
9,	102,857	50°	49°	-	May 5,	.0026	.0128	4.42	1.5400	.0008	.12	58
16,	102,857	56°	54°	-	12,	.0032	.0136	4.69	1.9900	.0014	.08	120
23,	102,857	55°	56°	-	19,	.0020	.0112	3.10	2.2300	.0012	.15	45
30,	102,857	60°	58°	-	26,	.0018	.0140	4.63	2.4900	.0000	.14	69
June 6,	102,857	63°	60°	-	June 2,	.0020	.0170	4.92	2.4100	.0008	.15	2
13,	102,857	64°	64°	-	9,	.0018	.0126	4.87	2.2000	.0008	.12	64
20,	102,857	70°	65°	-	16,	.0048	.0184	14.75	2.4200	.0060	.17	28
27,	102,857	67°	65°	-	23,	.0006	.0202	20.24	2.5100	.0034	.15	0
July 4,	102,857	66°	65°	-	30,	.0038	.0172	5.58	3.3400	.0022	.18	1
11,	102,857	67°	66°	-	July 7,	.0024	.0180	8.60	3.3000	.0036	.16	-
18,	102,857	73°	71°	-	14,	.0026	.0160	5.96	2.9900	.0022	.19	30
25,	102,857	73°	69°	-	21,	.0068	.0206	27.30	3.2900	.0050	.22	280
Aug. 1,	102,857	70°	66°	-	28,	.0034	.0210	21.70	3.0800	.0022	.17	178
8,	102,857	70°	69°	-	Aug. 4,	.0066	.0170	5.53	2.5400	.0044	.15	15
15,	102,857	74°	73°	-	11,	.0118	.0196	6.20	3.3000	.0052	.16	17
22,	102,857	73°	71°	-	18,	.0190	.0178	6.58	2.9700	.0080	.17	20

Sewage applied 6 times a week.

Surface raked about 1 inch deep each week until February 29; afterwards 3 inches deep.

Experiments interrupted by high water in the river, January 24-26, February 27-March 1, March 12-16, 23-29, April 12-18, 20, 21.

Effluent clear and colorless.

FILTER TANK NO. 19 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
Aug. 29,	102,857	73°	72°	-	Aug. 25,	.0300	.0248	8.34	2.4800	.0060	.20	2,580
Sept. 5,	102,857	68°	66°	-	Sept. 1,	.0192	.0166	5.98	2.3100	.0070	.17	1,280
12,	102,857	65°	64°	-	8,	.0512	.0152	13.97	1.9300	.0090	.18	192
19,	102,857	67°	67°	-	15,	.0198	.0170	6.10	2.1800	.0044	.18	860
26,	102,857	69°	69°	-	22,	.0282	.0208	7.11	3.2700	.0080	.25	44
Oct. 3,	102,857	69°	66°	-	29,	.0290	.0216	20.10	2.5000	.0060	.25	43
10,	102,857	65°	60°	-	Oct. 6,	.0254	.0178	8.98	2.3500	.0080	.17	690
17,	102,857	56°	54°	-	13,	.0246	.0106	8.83	1.8700	.0050	.20	25
24,	102,857	51°	52°	-	20,	.0360	.0180	6.63	2.2700	.0050	.19	11
31,	102,857	46°	48°	-	27,	.0760	.0220	6.55	2.7700	.0060	.21	122
Nov. 7,	60,000	46°	45°	-	Nov. 3,	.0740	.0280	6.98	1.8200	.0130	.19	13
14,	51,429	45°	51°	-	10,	.0330	.0130	6.80	1.8300	.0040	.20	2
21,	51,429	46°	48°	-	17,	.0312	.0154	9.18	2.7000	.0060	.18	5
28,	51,429	43°	50°	-	24,	.0460	.0160	6.90	2.8100	.0100	.33	0
Dec. 5,	51,429	40°	46°	1h. 30m.	Dec. 1,	.0238	.0136	6.02	2.0900	.0050	.17	1
12,	51,429	44°	47°	17m.	8,	.0324	.0204	7.87	1.5800	.0040	.18	1
19,	51,429	45°	44°	19m.	15,	.0248	.0152	6.23	2.0500	.0040	.16	2
26,	51,429	45°	48°	-	22,	.0246	.0142	8.20	1.8200	.0060	.17	0
					29,	.0256	.0160	8.55	1.5600	.0046	.20	3

Sewage applied 6 times a week.
Surface raked about 3 inches deep each week.
Effluent clear and colorless.

Summary of Eighteen Microscopical Examinations of Effluent of Filter Tank No. 19.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ. Palmella,	5	47	850
Fungi. Saccharomyces,	16	38	400
ANIMALS.			
Infusoria. Monas,	5	1.5	25

FILTER TANK No. 25.

This tank, 20 inches in diameter and 12 feet high, in which was buried, Dec. 18, 1889, the carcass of a dog, above five feet of sand and loam and beneath six feet of sand, loam and soil, was described in the report upon the Purification of Sewage and Water (page 689). The more recent results are shown by the following table: —

FILTER TANK NO. 25.

Date.	City Water Applied. — Gallons per Acre Daily.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.								
December,	8,600	23.7500	1.7500	1.03	.0950	.0525	3.95	96
1891.								
January,	8,600	21.2500	1.3000	.64	.2700	.0420	3.05	362
February,	8,600	16.7500	1.1000	.54	.0150	.0180	1.75	10
March,	3,871	12.0000	.6000	.51	.0100	.0011	1.60	52
April,	8,600	11.8750	.5500	.41	.0165	.0003	1.00	3
May,	8,600	9.2500	.4250	.34	.0010	.0018	.85	5
June,	8,600	7.5000	.4000	.36	.0020	.0020	.75	0
July,	8,600	6.5000	.2500	.45	.0000	.0010	.50	-
August,	8,600	6.5000	.1400	.28	.0000	.0000	.38	0
September,	8,600	5.3000	.2400	.25	.0000	.0004	.35	1
October,	8,600	5.7000	.1200	.35	.0000	.0020	.44	18
November,	8,600	6.0000	.1600	.37	.1600	.0080	.44	0
December,	8,600	4.7500	.1200	.30	.1000	.0120	.53	15

Three gallons city water applied each week.
Trap attached to outlet Dec. 20, 1890.

The effluent has been uniformly discolored by iron, and has had a strong and offensive odor, which has, however, decreased somewhat with the steady reduction in organic matter. The small number of bacteria in the effluent since the outlet was trapped is remarkable.

FILTER TANKS Nos. 26 to 31.

These small tanks with 30 inches of filtering material were described in the report upon the Purification of Sewage and Water, page 690. They are 1.41 feet in diameter and 2.95 feet high. Nos. 26 and 29 were filled with gravel stones, Nos. 27 and 30 with No. 1 sand, and Nos. 28 and 31 with No. 9 sand. Nos. 26, 27 and 28 were started April 1, 1890, and Nos. 29, 30 and 31 two months later, the object being to determine the influence of season upon the commencement of nitrification. The general result obtained, as given in the preceding report, was that with the filters started in June nitrification was obtained in from one-third to one-half the time required for those started in April.

Up to July 24, Nos. 26 and 29 (gravel stones) received sewage at the rate of 12,000 gallons per acre daily applied in four equal portions; after that date 27,500 gallons were applied in nine portions, and this rate has been continued on No. 29, but with No. 26 the quantity was reduced to 19,400 gallons on Aug. 7, 1891, after a year's work. The quantity applied to the other four filters of sand has been uniformly 48,000 gallons per acre daily. Up to July 24, 1890, the whole quantity was applied at once, but after that date it was divided into four equal portions applied at intervals during the day.

Up to April 10, 1891, the two sets of filters, Nos. 26, 27 and 28, and Nos. 29, 30 and 31, received in every way the same treatment, with the exception that the first three were started eight weeks earlier than the others. After this date concentrated sewage was applied to the first three and an equal amount of ordinary sewage to the others. The concentrated sewage is prepared as follows: A barrel is filled with normal sewage and is allowed to stand four hours. Four-fifths of the supernatant liquid is then drawn off, and the remaining fifth is thoroughly mixed with the sludge which has settled to the bottom during the four hours' rest. The soluble constituents of the sewage are not changed in any way; the insoluble matters are increased to about four and one-half times those of the original sewage.

For a time the filters to which the concentrated sewage was applied gave very nearly or quite as good effluents as the others; later the nitrates in the effluents were lower with the concentrated sewage although the total nitrogen applied was much greater. The sand examinations, Nov. 16, 1891, showed the reason for this. There had been a greater accumulation of organic matters in the upper layers of the filters receiving concentrated sewage; this had increased the water capacity until air was almost excluded, and the nitrates had been lower simply because there was not air enough in the filter to oxidize more nitrogen. On Nov. 16, 1891, the upper six inches of Filter 27 contained, after draining twenty-four hours, 29 per cent. of water by volume; Filter 30 held only 13 per cent. The air spaces were 11 and 27 per cent. respectively. With Filters 28 and 31 the air spaces in the upper six inches were 2 and 23 per cent. These water and air volumes are well shown by the diagram, page 439. Enough air had evidently passed, even with the smaller air spaces, to oxidize most of the organic matters, for good purification had been maintained; but there was not enough to allow as complete nitrification as was obtained where the air spaces were greater.

This increased storage of nitrogen with concentrated sewage has been discussed under the heading "Permanency of Filters," page 451. On Nov. 1, 1891, the method of applying sewage to Nos. 27, 28, 30 and 31 was changed, the whole daily quantity being applied at once instead of in four portions; and on November 20 the upper twelve inches of sand in Nos. 27 and 28 were inverted, in the same way that No. 14 had previously been treated.

The work of these filters can be divided into periods as follows: up to July 31, 1890, which includes the commencement of nitrification and treatment with comparatively large single doses of sewage; August, 1890, to March, 1891, when the two sets of filters were treated exactly alike, all receiving small doses at frequent intervals; April to October, 1891, when Nos. 26, 27 and 28 received concentrated and the others normal sewage, the quantities for the two sets being the same, except that it was necessary to reduce slightly the dose on No. 26 (stones) to prevent the passage of excessive quantities of suspended matter; and November and December, 1891, when Nos. 27 and 28 became clogged and required to have their surfaces changed.

First Period.

	Quantity Applied. — Gallons per Acre Daily.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Sewage, April—July, 1890, ...	-	1.8800	.6500	5.28	0	0	2.80	1,215,000
Effluents:								
Filter 26, stones, ...	18,000	.1329	.0759	6.17	1.30	.0087	.28	36,514
Filter 27, No. 1 sand, ...	47,000	.2958	.0903	5.05	1.45	.0303	.31	43,636
Filter 28, No. 9 sand, ...	47,000	.2995	.0415	5.24	1.37	.0120	.16	37,787
Sewage, June, July, 1890, ...	-	2.1400	.6900	5.70	0	0	2.86	1,215,000
Effluents:								
Filter 29, stones, ...	12,600	.0395	.0204	6.32	.99	.0143	.22	7,065
Filter 30, No. 1 sand, ...	46,000	.0514	.0209	5.21	1.25	.0058	.11	12,501
Filter 31, No. 9 sand, ...	47,000	.2495	.0317	4.79	1.10	.0654	.25	718

Second Period.

	Quantity Applied. — Gallons per Acre Daily.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Sewage, August, 1890—March, 1891, . .	-	1.7400	.6400	5.39	0	0	3.23	1,000,000
Effluents:								
Filter 26, stones, ...	27,000	.0645	.0480	6.12	1.43	.0014	.29	15,840
Filter 29, stones, ...	28,000	.0302	.0287	5.81	1.64	.0001	.20	10,719
Filter 27, No. 1 sand, ...	47,000	.0181	.0184	5.93	1.61	.0009	.16	2,298
Filter 30, No. 1 sand, ...	47,000	.0082	.0126	6.54	1.69	.0005	.11	601
Filter 28, No. 9 sand, ...	47,000	.0068	.0152	7.06	1.71	.0004	.15	73
Filter 31, No. 9 sand, ...	45,000	.0076	.0136	6.48	1.67	.0012	.13	150

Third Period.

	Quantity Applied. — Gallons per Acre Daily.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Concentrated sewage, April—October, 1891,	-	2.5300	1.9800	6.68	0	0	8.60	1,780,000
Normal sewage, April—October, 1891, .	-	2.4700	.7300	8.46	0	0	3.49	815,000
Effluents:								
Filter 26, stones, concentrated sewage, .	23,500	.0937	.2703	9.29	3.35	.1069	1.43	34,171
Filter 29, stones, normal sewage, . .	28,600	.0555	.0644	8.42	2.67	.0043	.38	12,000
Filter 27, No. 1 sand, concentrated sewage,	47,000	.0161	.0223	9.76	2.32	.0004	.21	3,070
Filter 30, No. 1 sand, normal sewage, .	47,000	.0341	.0172	9.00	2.93	.0026	.13	1,156
Filter 28, No. 9 sand, concentrated sewage,	47,000	.0186	.0212	9.37	2.70	.0010	.23	1,040
Filter 31, No. 9 sand, normal sewage, .	47,000	.0328	.0172	9.30	2.95	.0004	.15	191

Fourth Period.

	Quantity Applied. — Gallons per Acre Daily.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Concentrated sewage, November—December, 1891.	-	2.4700	2.2700	6.26	0	0	11.25	1,177,000
Normal sewage, November—December, 1891.	-	2.6900	1.0400	8.34	0	0	5.68	647,000
Effluents:								
Filter 26, stones, concentrated sewage, .	19,400	.1262	.4215	8.00	2.58	.1205	1.76	66,510
Filter 29, stones, normal sewage, . .	28,600	.1865	.0935	7.51	2.06	.0123	.48	75,000
Filter 27, No. 1 sand, concentrated sewage,	47,000	.1932	.0635	7.42	1.40	.0042	.38	19,066
Filter 30, No. 1 sand, normal sewage, .	47,000	.1782	.0542	7.40	1.88	.0139	.39	31,000
Filter 28, No. 9 sand, concentrated sewage,	47,000	1.0667	.0742	7.66	.84	.0155	.53	9,800
Filter 31, No. 9 sand, normal sewage, .	47,000	.1136	.0383	7.81	2.42	.0045	.26	16,275

Sand Examinations.—Filter Tanks 27, 28, 30 and 31.

Filters.	Date. 1891.	Depth of Sample. — Inches.	Water by Volume.	Air Space.	Ammonia. Free.	Ammonia. Albuminoid.	Total Nitrogen.	Bacteria per Gram.
No. 27, . . .	Nov. 16,	0-6	29	11	1.5	60.7	101.1	1,170,000
27, . . .	16,	6-12	11	29	0.8	5.5	9.7	260,000
27, . . .	16,	12-24	8	32	0.4	2.7	4.8	100,000
28, . . .	16,	0-6	40	2	3.9	61.1	103.8	475,000
28, . . .	16,	6-12	12	30	0.9	3.8	7.0	32,000
28, . . .	16,	12-24	13	29	0.6	2.4	4.4	46,000
30, . . .	16,	0-6	13	27	0.7	17.4	29.2	550,000
30, . . .	16,	6-12	10	30	0.6	4.0	7.1	170,000
30, . . .	16,	12-24	8	32	0.2	2.0	3.5	110,000
31, . . .	18,	0-6	19	23	1.1	21.4	36.1	2,035,000
31, . . .	18,	6-12	12	30	0.4	3.2	5.6	80,000
31, . . .	18,	12-24	12	30	0.1	1.34	2.3	17,000

Total Nitrogen, in Pounds.

	No. 27.	No. 28.	No. 30.	No. 31.
Present in the sand Nov. 16, 1891, ...	.0871	.0794	.0312	.0303
Originally present in the sand, ...	.0018	.0031	.0018	.0031
Total amount stored, ...	.0853	.0763	.0294	.0272

The weekly results are given in full in the following tables: —

FILTER TANK NO. 26.

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
April 5,	19,530	46°	50°	April 2,	.7000	.3000	4.60	.0000	.0000	1.25	164,340
				4,	.1800	.1900	4.82	.0300	.0020	.82	157,320
12,	11,957	45°	-	7,	.2000	.1900	4.77	.0200	.0100	-	79,704
				10,	.1600	.1800	6.06	.0100	.0070	.77	150,660
19,	8,968	45°	48°	14,	.5500	.2400	4.75	.0000	.0000	1.41	41,400
				17,	.2600	.1900	4.90	.0200	.0040	.29	65,340
26,	12,196	46°	-	21,	.2300	.1400	4.80	.0100	.0022	.27	-
				24,	.2360	.0620	5.22	.0100	.0018	.24	53,460
May 3,	12,196	48°	-	28,	.3000	.1000	4.82	.0100	.0022	.29	53,460
				May 1,	.3700	.2000	5.59	.0300	.0040	.29	32,232
10,	12,196	52°	-	5,	.3400	.1100	5.27	.1500	.0060	.35	35,640
				8,	.2700	.1100	4.95	.5500	.0120	.28	87,768
17,	12,196	56°	-	12,	.1350	.0820	4.75	1.8000	.0160	.27	7,290
				15,	.0760	.0540	5.18	2.6000	.0120	.15	13,800
24,	12,196	58°	-	19,	.0560	.0435	5.54	3.2500	.0180	.20	-
				22,	.0610	.0490	5.46	2.7500	.0100	.18	-
31,	12,196	58°	-	29,	.0312	.0420	5.67	2.2500	.0060	.17	7,772
June 7,	12,196	61°	-	June 5,	.0316	.0336	5.57	2.5000	.0044	.15	-
14,	12,196	62°	-	12,	.0194	.0268	5.77	1.6000	.0050	.10	10,620
21,	12,196	64°	-	19,	.0580	.0280	6.22	1.7500	.0600	.12	20,145
28,	12,196	71°	-	26,	.0220	.0140	6.65	1.9000	.0035	.08	1,687
July 5,	12,196	72°	-	July 3,	.0168	.0144	7.36	1.7500	.0060	.09	793
12,	11,678	72°	-	10,	.0336	.0264	9.31	1.6500	.0026	.08	-
19,	12,196	73°	-	17,	.0134	.0132	9.20	1.7500	.0024	.07	7,860
26,	19,849	71°	72°	24,	.0184	.0156	8.55	1.6500	.0020	.09	54,648
Aug. 2,	26,465	73°	77°	31,	.0112	.0320	7.34	1.1000	.0014	.14	-
9,	27,501	76°	76°	Aug. 7,	.0064	.0202	7.45	1.3500	.0010	.12	-
16,	27,501	73°	72°	14,	.0080	.0222	9.83	1.1000	.0010	.15	15,900
23,	27,501	72°	72°	21,	.0062	.0250	9.14	1.7500	.0006	.12	8,700
30,	27,501	67°	70°	28,	.0096	.0360	9.64	1.5000	.0006	.19	-
Sept. 6,	27,501	66°	70°	Sept. 4,	.0044	.0608	13.42	1.6000	.0006	.27	900
13,	27,501	68°	69°	11,	.0042	.0604	7.60	1.9000	.0008	.32	24,192

Sewage applied 6 times a week from April 1 to April 19, then 24 times a week till July 24, and afterwards 54 times a week.

Effluent generally slightly turbid.

FILTER TANK NO. 26 — *Continued.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
Sept. 20, .	27,501	66°	69°	Sept. 18, .	.0092	.0490	6.50	1.4000	.0008	.29	-
27, .	27,501	62°	64°	25, .	.0134	.0338	7.17	1.8500	.0006	.29	46,980
Oct. 4, .	27,501	60°	64°	Oct. 2, .	.0180	.0578	7.90	1.1500	.0012	-	12,120
11, .	27,501	59°	56°	9, .	.0372	.0448	6.20	1.4000	.0006	.30	4,260
18, .	27,501	54°	56°	16, .	.0112	.0334	6.17	1.3500	.0006	.19	77,054
25, .	22,918	50°	50°	23, .	.0785	.0635	5.77	1.1500	.0006	.40	17,520
Nov. 1, .	27,501	47°	49°	30, .	.0820	.0535	6.12	1.0000	.0016	.32	25,740
8, .	27,501	45°	51°	Nov. 6, .	.0660	.0420	6.90	1.4500	.0010	.26	51,212
15, .	27,501	45°	48°	13, .	.1050	.0750	7.27	1.3700	.0024	.40	8,640
22, .	27,501	42°	46°	20, .	.0570	.0510	5.32	.9900	.0010	.34	41,400
29, .	26,983	40°	47°	27, .	.0312	.0528	5.90	1.3000	.0016	.28	22,140
Dec. 6, .	27,501	45°	44°	Dec. 4, .	.1300	.0570	6.52	1.4100	.0020	.32	7,940
13, .	27,501	44°	47°	11, .	.1300	.0660	5.27	1.6000	.0024	.35	3,300
20, .	27,462	45°	44°	18, .	.1200	.0600	6.86	1.4600	.0022	.36	4,380
27, .	23,356	45°	45°	-	-	-	-	-	-	-	-
1891.											
Jan. 3, .	27,501	45°	44°	Jan. 1, .	.2000	.0660	4.22	1.4800	.0016	.36	10,200
10, .	27,501	45°	45°	8, .	.1440	.0520	6.02	1.0200	.0026	.34	3,600
17, .	27,501	46°	45°	15, .	.0655	.0420	3.98	1.3700	.0010	.19	1,660
24, .	26,983	45°	46°	22, .	.0960	.0460	4.42	1.5500	.0040	.32	550
31, .	22,922	44°	44°	29, .	.1200	.0720	4.39	1.8200	.0028	.34	2,280
Feb. 7, .	27,501	44°	43°	Feb. 5, .	.0740	.0424	3.82	1.6000	.0005	.28	8,100
14, .	27,501	44°	43°	12, .	.1032	.0476	5.46	1.3000	.0018	.34	660
21, .	27,501	45°	44°	19, .	.0532	.0580	3.79	1.3000	.0012	.39	2,820
28, .	27,501	44°	44°	26, .	.0204	.0378	3.87	1.4100	.0016	.32	1,440
March 7, .	27,501	44°	41°	March 5, .	.0475	.0360	3.82	1.1600	.0010	.25	2,280
14, .	22,922	44°	45°	12, .	.0536	.0336	3.54	1.4700	.0014	.28	2,640
21, .	22,922	44°	42°	19, .	.1260	.0460	3.50	1.7600	.0012	.34	2,820
28, .	7,658	-	44°	-	-	-	-	-	-	-	-
April 4, .	27,501	45°	45°	April 2, .	.0640	.0400	5.34	1.2300	.0009	.24	1,200
11, .	27,501	44°	45°	9, .	.0740	.0405	4.64	1.3000	.0009	.24	270,000
18, .	15,265	46°	52°	-	-	-	-	-	-	-	-
25, .	27,501	52°	57°	23, .	.2135	.0915	5.12	2.0200	.0034	.39	20,160

Sewage applied 54 times a week; ordinary sewage until April 8, afterwards concentrated sewage.
Surface raked about 1 inch deep each week, beginning December 26.
Experiments interrupted by high water in the river January 25, 26, March 14-16, 24-27, April 14-16.
Effluent generally turbid.

FILTER TANK NO. 26 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
May 2, .	27,501	50°	55°	April 30, .	.0505	.0535	7.24	2.1500	.0012	.28	32,040
9, .	27,501	50°	53°	May 7, .	.0800	.0840	5.47	2.0400	.0036	.45	3,480
16, .	27,501	56°	59°	14, .	.0432	.0880	8.15	2.1600	.0040	.47	38,000
23, .	27,501	55°	60°	21, .	.0400	.1400	5.48	1.8100	.0800	.84	19,620
30, .	27,501	60°	63°	28, .	.0620	.1500	10.28	2.6200	.1000	.70	12,060
June 6, .	27,501	63°	63°	June 4, .	.0700	.1700	12.00	3.6300	.0500	.83	156,600
13, .	27,501	64°	70°	11, .	.0940	.1760	15.82	4.1500	.0400	1.18	33,480
20, .	27,501	70°	67°	18, .	.0860	.3340	13.42	3.7500	.0500	2.00	12,060
27, .	27,501	67°	70°	25, .	.0900	.3540	11.24	3.4300	.1500	1.90	1,830
July 4, .	27,501	66°	69°	July 2, .	.0440	.1580	10.08	4.2200	.0130	.76	58
11, .	27,501	67°	69°	9, .	.0380	.1880	12.84	3.3400	.1500	.94	1,740
18, .	27,501	73°	76°	16, .	.0760	.4740	6.90	4.6200	.1600	2.04	8,000
25, .	27,501	73°	72°	23, .	.0580	.3240	16.60	4.2300	.1200	1.90	2,180
Aug. 1, .	27,501	70°	69°	30, .	.0660	.6000	16.80	2.6300	.4000	3.70	13,140
8, .	24,791	70°	73°	Aug. 6, .	.0580	.4200	7.46	3.5700	.2400	1.80	23,580
15, .	19,371	74°	77°	13, .	.1300	.5100	7.68	4.3500	.1600	4.20	2,450
22, .	19,371	78°	74°	20, .	.1000	.4600	7.25	2.8800	.3600	2.20	7,220
29, .	14,827	73°	74°	27, .	.0800	.3400	11.87	4.9000	.0500	1.50	4,440
Sept. 5, .	18,294	67°	69°	Sept. 3, .	.0600	.3500	8.80	4.5000	.0600	1.50	4,128
12, .	19,371	65°	68°	10, .	.0500	.2300	8.48	3.9200	.2200	1.70	21,240
19, .	19,371	67°	71°	17, .	.1200	.2700	7.48	4.1400	.1600	1.40	5,980
26, .	19,371	69°	72°	24, .	.0900	.2000	9.28	5.1300	.0800	1.20	732
Oct. 3, .	19,371	69°	70°	Oct. 1, .	.1400	.3500	11.18	4.6300	.1000	1.70	580
10, .	19,371	65°	61°	8, .	.1200	.4000	9.44	4.0000	.0700	1.54	6,390
17, .	19,371	56°	55°	15, .	.1400	.5100	8.50	3.8300	.1600	2.20	3,620
24, .	19,371	51°	53°	22, .	.2700	.4400	6.83	3.6900	.1800	2.20	314,000
31, .	19,371	46°	50°	29, .	.2200	.3900	10.38	2.5600	.1200	1.80	8,400
Nov. 7, .	19,371	45°	47°	Nov. 5, .	.1700	.4800	10.40	3.2500	.0400	1.90	21,980
14, .	19,371	45°	52°	12, .	.2300	.6400	8.43	2.2200	.2400	3.10	59,000
21, .	19,371	46°	50°	19, .	.2300	.5500	6.80	2.4000	.1800	2.00	90,000
28, .	18,653	43°	50°	25, .	.1400	.6300	6.92	2.2700	.1200	2.50	135,000
Dec. 5, .	19,371	40°	47°	Dec. 3, .	.0700	.2700	8.27	2.1000	.1800	.90	7,300
12, .	19,371	44°	49°	10, .	.0880	.3100	7.16	2.4500	.0300	1.20	29,700
19, .	19,371	45°	46°	17, .	.0360	.2260	8.52	2.8200	.0240	1.06	145,000
26, .	17,936	43°	49°	31, .	.0460	.2660	7.52	2.7400	.1500	1.44	44,900

Concentrated sewage applied 54 times a week.
Surface raked about 1 inch deep each week.
Effluent generally turbid and with much sediment.

Summary of Fifteen Microscopical Examinations of Effluent of Filter Tank No. 26.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Algæ. Ulothrix,	7	3.3	50
Fungi. Saccharomyces,	60	2,225	9,400
ANIMALS.			
Rhizopoda. Amœba,	27	100	1,200
Infusoria.			
Euglena,	7	3.3	50
Monas,	80	1,675	7,200
Paramæcium,	93	1,385	3,200
Vorticella,	7	8	125
Vermes.			
Anguillula,	40	260	1,800
Rotifer,	20	13	100
Rotatorian ova,	20	40	300

FILTER TANK NO. 27.

WEEK ENDING —	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE. Sewage.	TEMPERATURE. Effluent.	Date of Sample.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
April 5,	47,829	46°	48°	April 2,	.1700	.0300	3.27	.0400	.0020	.45	12,870
				4,	.2400	.0900	4.90	.0300	.0140	.29	35,964
12,	47,829	45°	47°	7,	.1240	.0520	4.54	.0100	.0030	.19	272,370
				10,	.2200	.0400	4.68	.0200	.0030	.21	56,376
19,	47,829	46°	50°	14,	.1900	.0600	4.32	.0200	.0200	.45	11,660
				17,	.5000	.1300	4.60	.0200	.0030	.23	6,300
26,	47,829	46°	51°	21,	.6500	.2100	3.93	.0300	.0050	.32	53,460
				24,	.7800	.1300	4.02	.0200	.0080	.25	85,360
May 3,	47,829	48°	54°	28,	1.1000	.1400	4.10	.0900	.0120	.35	87,480
				May 1,	1.1000	.1300	4.90	.3500	.0200	.31	108,576
10,	47,829	52°	58°	5,	1.1500	.1300	4.10	.5000	.0500	.28	102,060
				8,	.8000	.1200	4.74	2.0000	.0500	.24	136,556
17,	47,829	56°	62°	12,	.2500	.0600	3.97	4.0000	.0900	.25	29,574
				15,	.0525	.0415	4.87	2.7500	.0220	.19	102,400

Sewage applied 6 times a week.
Effluent generally slightly turbid.

FILTER TANK NO. 27 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
May 24,	47,829	58°	63°	May 19,	.0186	.0668	5.27	2.7500	.0160	.22	2,030
				22,	.0365	.0515	5.28	2.6000	.0090	.18	16,848
31,	47,829	58°	61°	29,	.0116	.0432	4.73	2.0000	.0050	.17	23,780
June 7,	47,829	61°	62°	June 5,	.0108	.0454	5.34	2.2500	.0060	.15	-
14,	47,829	62°	63°	12,	.0280	.0620	5.02	1.5000	.0140	.22	19,104
21,	47,829	64°	70°	19,	.0366	.0730	5.65	1.7500	.0800	.24	101,952
28,	47,829	71°	71°	26,	.1370	.0770	5.27	1.6500	.0100	.32	8,100
July 5,	47,829	72°	74°	July 3,	.2940	.1340	6.22	1.3700	.0050	1.10	73,350
12,	47,829	72°	70°	10,	.3120	.1640	5.76	2.1000	.0070	.39	-
19,	47,829	73°	74°	14,	.4400	.1680	5.59	1.3500	.2200	.60	111,510
				17,	.3800	.1900	6.97	1.7500	.1900	.57	74,340
26,	47,829	71°	70°	21,	.6400	.2280	5.12	1.3900	.0030	.94	42,660
				24,	.0088	.0246	5.46	2.8500	.0004	.14	410
Aug. 2,	47,829	73°	76°	31,	.0064	.0218	6.78	2.5000	.0004	.13	343
9,	47,829	76°	76°	Aug. 7,	.0062	.0196	7.72	2.2500	.0004	.12	993
16,	47,829	73°	71°	14,	.0030	.0194	10.32	1.9000	.0004	.12	5,251
23,	47,829	72°	71°	21,	.0030	.0198	8.77	1.8500	.0002	.14	2,640
30,	47,829	67°	70°	28,	.0064	.0222	7.77	1.8500	.0000	.13	-
Sept. 6,	47,829	66°	69°	Sept. 4,	.0096	.0216	10.14	1.6000	.0002	.16	588
13,	47,829	68°	69°	11,	.0028	.0166	6.38	2.2500	.0004	.13	968
20,	47,829	66°	69°	18,	.0030	.0212	7.34	1.8500	.0000	.19	61
27,	47,829	62°	63°	25,	.0030	.0170	6.54	1.7500	.0000	.16	3,009
Oct. 4,	47,829	60°	63°	Oct. 2,	.0016	.0172	8.37	1.8000	.0002	-	422
11,	47,829	59°	57°	9,	.0008	.0154	6.94	1.5000	.0000	.16	795
18,	47,829	54°	56°	16,	.0130	.0150	6.02	1.4000	.0004	.18	2,400
25,	39,857	50°	50°	23,	.1360	.0315	5.65	.9500	.0004	.21	19,883
Nov. 1,	47,829	47°	49°	30,	.2320	.0240	6.00	1.4000	.0030	.21	12,960
8,	47,829	45°	50°	Nov. 6,	.0620	.0220	5.95	1.7300	.0090	.18	590
15,	47,829	45°	47°	13,	.0088	.0136	7.29	1.4400	.0002	.16	1,920
22,	47,829	42°	45°	20,	.0034	.0196	5.32	1.3200	.0004	.15	1,520
29,	47,829	40°	47°	27,	.0312	.0320	6.35	1.2900	.0030	.21	360
Dec. 6,	47,829	45°	44°	Dec. 4,	.0342	.0212	7.73	1.6700	.0060	.16	1,470

Sewage applied 6 times a week until July 24; afterwards 24 times a week.
Surface raked about 1 inch deep each week, commencing October 29.
Effluent generally turbid until July 21; afterwards clear and nearly colorless.

FILTER TANK NO. 27 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
Dec. 13,	47,829	45°	46°	Dec. 11,	.0010	.0162	4.76	1.8000	.0090	.16	780
20,	47,829	45°	44°	18,	.0064	.0172	4.42	1.7000	.0006	.16	560
27,	43,843	45°	44°	-	-	-	-	-	-	-	-
1891.											
Jan. 3,	47,829	45°	44°	Jan. 1,	.0650	.0215	4.28	1.4400	.0007	.18	940
10,	47,829	45°	44°	8,	.0076	.0146	6.60	1.7300	.0020	.13	160
17,	47,829	46°	45°	15,	.0014	.0134	3.50	1.3500	.0000	.08	260
24,	45,836	45°	46°	22,	.0020	.0176	4.58	1.6600	.0006	.15	448
31,	39,857	44°	43°	29,	.0018	.0192	4.17	1.9200	.0002	.15	152
Feb. 7,	47,829	44°	43°	Feb. 5,	.0016	.0162	3.97	1.7200	.0001	.20	68
14,	47,829	44°	43°	12,	.0010	.0170	6.20	1.3900	.0001	.19	100
21,	47,829	45°	43°	19,	.0030	.0160	3.84	1.2600	.0001	.19	7
28,	47,829	44°	44°	26,	.0016	.0184	4.24	1.4300	.0001	.19	1,100
March 7,	47,829	44°	44°	March 5,	.0014	.0138	3.82	1.2000	.0000	.14	128
14,	39,857	44°	45°	12,	.0024	.0130	3.70	1.5800	.0001	.16	280
21,	39,857	44°	42°	19,	.0010	.0116	3.12	1.8100	.0002	.15	92
28,	13,950	-	44°	-	-	-	-	-	-	-	-
April 4,	47,829	45°	45°	April 2,	.0064	.0134	5.67	1.6500	.0004	.13	72
11,	47,829	44°	45°	9,	.0312	.0172	4.53	1.5000	.0006	.20	5,760
18,	25,907	45°	49°	-	-	-	-	-	-	-	-
25,	47,829	52°	56°	23,	.0114	.0154	5.52	2.4000	.0001	.13	38
May 2,	47,829	51°	55°	30,	.0014	.0186	10.10	2.1400	.0002	.14	340
9,	47,829	50°	52°	May 7,	.0240	.0176	5.20	2.4400	.0003	.13	70
16,	47,829	56°	58°	14,	.0026	.0208	10.00	2.7900	.0005	.14	94
23,	47,829	55°	60°	21,	.0014	.0154	5.10	2.2000	.0000	.20	94
30,	47,829	60°	62°	28,	.0548	.0234	10.55	3.1200	.0008	.19	1,260
June 6,	47,829	63°	63°	June 4,	.0040	.0264	13.45	3.6500	.0004	.24	4,500
13,	47,829	64°	70°	11,	.0058	.0242	16.16	2.5100	.0000	.17	122
20,	47,829	70°	67°	18,	.0032	.0260	11.78	2.6400	.0006	.25	133
27,	47,829	67°	69°	25,	.0666	.0236	12.58	1.7100	.0014	.27	820
July 4,	47,829	67°	69°	July 2,	.0078	.0216	10.34	1.8400	.0002	.25	203
11,	47,829	67°	69°	9,	.0040	.0218	13.14	1.5400	.0000	.23	2,820

Sewage applied 24 times a week; ordinary sewage until April 11, afterwards concentrated sewage.

Surface raked about 1 inch deep each week from October 29 to April 17, afterwards about 3 inches deep each week.

Experiments interrupted by high water in the river January 25, 26, March 14-16, 23-27, April 16.

Effluent generally clear and nearly colorless.

FILTER TANK NO. 27 — *Concluded.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
July 18, .	47,829	73°	75°	July 16, .	.0040	.0240	6.40	2.5500	.0000	.31	24
25, .	47,829	73°	72°	23, .	.0038	.0264	18.25	1.8500	.0002	.24	-
Aug. 1, .	47,829	70°	68°	30, .	.0024	.0246	18.24	1.8500	.0002	.24	158
8, .	47,829	70°	72°	Aug. 6, .	.0036	.0250	6.86	2.4600	.0003	.19	672
15, .	45,836	74°	76°	13, .	.0036	.0276	7.70	4.9200	.0002	.28	136
22, .	47,829	73°	74°	20, .	.0024	.0202	6.70	2.2300	.0003	.24	522
29, .	47,829	73°	74°	27, .	.0020	.0226	14.34	2.7700	.0002	.19	560
Sept. 5, .	47,829	68°	68°	Sept. 3, .	.0016	.0150	8.36	2.2000	.0001	.19	480
12, .	45,836	65°	68°	10, .	.0064	.0334	8.25	1.8500	.0005	.24	37,080
19, .	47,829	67°	70°	17, .	.0030	.0198	7.10	2.3300	.0002	.22	242
26, .	47,829	69°	71°	24, .	.0022	.0198	10.66	2.7700	.0002	.22	558
Oct. 3, .	47,829	69°	69°	Oct. 1, .	.0600	.0320	9.72	2.0600	.0004	.23	32,760
10, .	47,829	65°	61°	8, .	.0024	.0214	8.98	1.9800	.0004	.26	306
17, .	47,829	56°	55°	15, .	.1100	.0340	8.96	1.5400	.0006	.24	2,100
24, .	47,829	51°	53°	22, .	.0066	.0154	7.08	1.4900	.0020	.21	384
31, .	47,829	46°	51°	29, .	.0660	.0280	14.67	1.5800	.0008	.24	966
Nov. 7, .	47,829	45°	47°	Nov. 6, .	.3200	.0420	9.86	1.2800	.0024	.29	11,720
14, .	47,829	45°	52°	12, .	.4000	.0420	7.30	2.5300	.0050	.31	16,380
21, .	47,829	46°	50°	19, .	.1500	.0400	6.40	1.7300	.0036	.22	2,300
28, .	47,829	43°	49°	25, .	.1300	.0660	6.40	.9500	.0040	.31	50,000
Dec. 5, .	47,829	40°	46°	Dec. 3, .	.0900	.0680	7.98	1.0200	.0024	.80	13,600
12, .	47,829	44°	49°	10, .	.3200	.1720	7.16	.2600	.0130	.72	56,000
19, .	47,829	45°	45°	17, .	.1360	.0400	8.38	1.5600	.0020	.33	100
26, .	47,829	45°	49°	24, .	.0900	.0520	7.42	1.5200	.0036	.30	20,160
				31, .	.0460	.0660	5.88	1.5100	.0026	.23	300

Concentrated sewage applied 24 times a week till October 31, afterwards 6 times a week.
Surface raked about 3 inches deep each week.
November 20, upper foot of sand inverted.
Effluent generally clear and nearly colorless until October 29, afterwards slightly turbid.

Summary of Fifteen Microscopical Examinations of Effluent of Filter Tank No. 27.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Fungi. Molds,	7	3.3	50
ANIMALS.			
Infusoria. Paramæcium,	7	3.3	50
Vermes. Anguillula,	7	3.3	50
Miscellaneous. Starch,	7	3.3	50

Filter Tank No. 28.

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
April 5,	47,829	46°	49°	April 2,	.0500	.0300	1.82	.0400	.0006	.33	7,425
				4,	.1500	.1100	4.02	.0400	.0016	.40	12,528
12,	47,829	45°	46°	7,	.1360	.0750	4.67	.0100	.0000	.24	56,160
				10,	.3000	.0500	4.47	.0100	.0060	.23	120,780
19,	47,829	46°	50°	14,	.3000	.0500	5.19	.0100	.0012	.20	106,920
				17,	.5000	.0900	4.08	.0200	.0020	.17	23,485
26,	47,829	46°	52°	21,	.6000	.0900	4.25	.0100	.0006	.16	134,550
				24,	1.0500	.0800	3.79	.0100	.0022	.17	62,208
May 3,	47,829	48°	54°	28,	1.2000	.0800	4.36	.0200	.0060	.18	102,060
				May 1,	1.1500	.1200	4.14	.0300	.0080	.19	110,790
10,	47,829	52°	58°	5,	1.1500	.0900	5.02	.0800	.0180	.24	100,980
				8,	1.4500	.1000	4.67	.5500	.0600	.23	142,290
17,	47,829	56°	62°	12,	1.0500	.0500	4.40	1.2000	.0300	.22	157
				15,	.7000	.0600	4.44	2.6000	.1100	.29	96
24,	47,829	58°	63°	19,	.1330	.0210	4.13	2.6000	.0300	.13	5,220
				22,	.0395	.0205	5.90	2.7500	.0240	.15	15,138
31,	47,829	58°	60°	29,	.0056	.0172	8.27	2.0000	.0040	.12	5,768
June 7,	47,829	61°	62°	June 5,	.0026	.0154	5.32	2.4000	.0014	.08	-

Sewage applied 6 times a week.
Effluent generally slightly turbid.

FILTER TANK NO. 28 — *Continued.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
June 14, .	47,829	62°	62°	June 12, .	.0040	.0160	4.84	2.1500	.0040	.12	27,140
21, .	47,829	64°	69°	19, .	.0162	.0184	4.77	1.6500	.0200	.12	532
28, .	47,829	71°	71°	26, .	.0060	.0170	6.00	2.0000	.0040	.12	16
July 5, .	47,829	72°	74°	July 3, .	.0082	.0196	6.94	1.7500	.0040	.13	6,000
12, .	47,829	72°	72°	10, .	.0066	.0138	5.99	2.3500	.0100	.11	20,592
19, .	47,829	73°	74°	17, .	.0022	.0142	5.93	2.0000	.0000	.11	175
26, .	47,829	71°	70°	24, .	.0040	.0168	7.02	1.7500	.0002	.10	133
Aug. 2, .	47,829	73°	77°	31, .	.0030	.0186	6.82	1.8500	.0002	.10	251
9, .	47,829	76°	76°	Aug. 7, .	.0022	.0188	8.92	2.0000	.0000	.10	92
16, .	47,829	73°	71°	14, .	.0026	.0180	12.62	2.2500	.0000	.12	86
23, .	47,829	72°	73°	21, .	.0082	.0162	10.22	2.0000	.0000	13	57
30, .	47,829	67°	70°	28, .	.0038	.0144	15.47	2.0000	.0000	.11	5
Sept. 6, .	47,829	66°	69°	Sept. 4, .	.0046	.0178	6.14	2.3000	.0000	.19	2
13, .	47,829	68°	69°	11, .	.0152	.0152	6.87	1.8500	.0004	.13	-
20, .	47,829	66°	69°	18, .	.0012	.0116	5.77	1.7000	.0000	.13	7
27, .	47,829	62°	63°	25, .	.0040	.0096	7.05	1.8500	.0000	.17	79
Oct. 4, .	47,829	60°	64°	Oct. 2, .	.0062	.0160	7.92	1.4000	.0004	-	81
11, .	47,829	59°	57°	9, .	.0008	.0122	6.33	1.9000	.0000	.14	36
18, .	47,829	54°	56°	16, .	.0028	.0124	8.46	1.4000	.0000	.16	61
25, .	39,857	50°	50°	23, .	.0030	.0138	4.15	1.1500	.0002	.12	482
Nov. 1, .	47,829	47°	49°	30, .	.0910	.0190	6.10	1.6000	.0016	.21	349
8, .	47,829	45°	50°	Nov. 6, .	.0076	.0192	8.15	1.6500	.0004	.16	20
15, .	47,829	45°	47°	13, .	.0016	.0174	8.42	1.5600	.0002	.18	37
22, .	47,829	42°	46°	20, .	.0140	.0170	5.02	1.5800	.0006	.18	24
29, .	47,829	40°	47°	27, .	.0140	.0186	5.87	1.7700	.0012	.16	2
Dec. 6, .	47,829	45°	44°	Dec. 4, .	.0172	.0180	15.38	1.7100	.0025	.17	52
13, .	47,829	45°	46°	11, .	.0040	.0150	6.00	1.8000	.0008	.14	64
20, .	47,829	46°	44°	18, .	.0044	.0162	4.70	1.3500	.0000	.20	44
27, .	43,843	43°	44°	-	-	-	-	-	-	-	-
1891.											
Jan. 3, .	47,829	45°	43°	Jan. 1, .	.0010	.0120	4.32	1.5900	.0000	.14	44
10, .	47,829	45°	44°	8, .	.0024	.0144	16.50	1.8600	.0001	.15	68

Sewage applied 6 times a week until July 24, afterwards 24 times a week.
Surface raked about 1 inch deep each week, commencing October 15.
Effluent generally clear and practically colorless.

FILTER TANK NO. 28 — *Continued.*

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Jan. 17, .	47,829	46°	45°	Jan. 15, .	.0002	.0106	3.14	1.2300	.0000	.10	20
24, .	45,836	45°	45°	22, .	.0016	.0126	4.61	1.6100	.0002	.13	20
31, .	39,857	44°	43°	29, .	.0024	.0146	4.05	2.0100	.0001	.14	29
Feb. 7, .	47,829	44°	43°	Feb. 5, .	.0004	.0184	4.59	1.8600	.0000	.16	13
14, .	47,829	44°	43°	12, .	.0006	.0150	7.74	1.8100	.0003	.19	44
21, .	47,829	45°	43°	19, .	.0016	.0142	4.77	1.4900	.0003	.18	3
28, .	47,829	44°	44°	26, .	.0038	.0164	5.67	1.5500	.0007	.19	40
March 7, .	47,829	44°	40°	March 5, .	.0024	.0126	4.27	1.2000	.0000	.16	104
14, .	39,857	44°	45°	12, .	.0014	.0136	4.30	1.7200	.0001	.16	16,380
21, .	39,857	44°	42°	19, .	.0024	.0130	3.04	1.8600	.0010	.16	360
28, .	13,950	-	44°	-	-	-	-	-	-	-	-
April 4, .	47,829	44°	45°	April 2, .	.0218	.0218	5.40	1.7900	.0012	.13	20
11, .	47,829	44°	45°	9, .	.0048	.0146	4.27	1.4300	.0012	.16	400
18, .	25,907	45°	49°	-	-	-	-	-	-	-	-
25, .	47,829	52°	57°	23, .	.0258	.0142	5.27	2.3300	.0003	.12	50
May 2, .	47,829	51°	56°	30, .	.0028	.0154	8.65	1.8200	.0020	.15	41
9, .	47,829	50°	52°	May 7, .	.0268	.0140	5.24	2.0900	.0010	.16	16
16, .	47,829	56°	58°	14, .	.0030	.0168	9.42	3.3000	.0014	.13	64
23, .	47,829	55°	60°	21, .	.0004	.0142	5.16	2.2000	.0000	.21	31
30, .	47,829	60°	63°	28, .	.0020	.0202	7.48	3.5200	.0004	.21	20
June 6, .	47,829	63°	63°	June 4, .	.0044	.0206	10.02	3.7400	.0008	.18	640
13, .	47,829	64°	70°	11, .	.0040	.0212	13.87	2.5000	.0016	.17	97
20, .	47,829	70°	67°	18, .	.0026	.0250	13.84	3.4300	.0004	.29	110
27, .	47,829	67°	69°	25, .	.0046	.0290	12.14	2.5500	.0004	.35	0
July 4, .	47,829	67°	70°	July 2, .	.0028	.0250	11.22	2.8600	.0000	.28	40
11, .	47,829	67°	69°	9, .	.0038	.0294	14.82	2.8600	.0000	.26	22
18, .	47,829	73°	76°	16, .	.0030	.0290	6.56	4.4000	.0002	.30	2
25, .	47,829	73°	73°	23, .	.0024	.0260	18.35	2.8600	.0004	.26	-
Aug. 1, .	47,829	70°	69°	30, .	.0022	.0270	22.26	3.2100	.0007	.27	606
8, .	47,829	70°	73°	Aug. 6, .	.0124	.0236	6.10	3.2900	.0016	.22	19,548
15, .	45,836	74°	76°	13, .	.0030	.0210	7.92	3.4300	.0000	.25	150
22, .	47,829	73°	74°	20, .	.0032	.0238	6.78	3.1700	.0007	.26	1,908

Sewage applied 24 times a week, ordinary sewage until April 11, afterwards concentrated sewage.
Surface raked about 1 inch deep each week until April 17, afterwards about 3 inches deep each week.
Experiments interrupted by high water in the river January 25, 26, March 14-16, 23-27, April 14-16.
Effluent generally clear and practically colorless.

FILTER TANK NO. 28 — *Concluded.*

Week Ending—	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Aug. 29,	47,829	73°	74°	Aug. 27,	.0040	.0232	12.46	2.9900	.0003	.26	150
Sept. 5,	47,829	68°	68°	Sept. 3,	.0030	.0170	6.73	2.8100	.0001	.24	168
12,	45,836	65°	68°	10,	.0028	.0188	10.56	3.0800	.0002	.24	46
19,	47,829	67°	70°	17,	.0040	.0198	6.66	2.7300	.0004	.23	2,000
26,	47,829	69°	72°	24,	.0040	.0206	10.53	2.8600	.0001	.24	366
Oct. 3,	47,829	70°	69°	Oct. 1,	.0034	.0226	12.84	2.4700	.0002	.23	165
10,	47,829	65°	61°	8,	.0028	.0186	9.00	2.1100	.0002	.28	222
17,	47,829	56°	55°	15,	.1400	.0320	9.00	1.5500	.0030	.24	227
24,	47,829	51°	53°	22,	.0184	.0180	6.91	1.4800	.0000	.24	882
31,	47,829	46°	50°	29,	.3000	.0220	11.54	1.8500	.0110	.27	1,780
Nov. 7,	31,886	45°	46°	Nov. 6,	1.8000	.0880	10.46	.0100	.0008	.72	23,760
14,	47,829	45°	51°	12,	2.2000	.0800	8.13	.4400	.0036	52	802
21,	39,857	46°	50°	19,	1.8000	.1060	8.06	.1000	.0000	.77	11,187
28,	47,829	48°	49°	25,	1.6600	.1100	6.25	1.3600	.0600	.42	1,900
Dec. 5,	47,829	40°	47°	Dec. 3,	.3000	.0440	8.63	1.4000	.0500	.88	8,000
12,	47,829	44°	49°	10,	.0800	.0360	6.75	1.5600	.0060	.28	2,200
19,	47,829	45°	45°	17,	.0320	.0800	7.40	1.6400	.0050	.26	15,000
26,	47,829	45°	49°	24,	.1100	.0500	6.64	1.1800	.0046	.35	10,000
				31,	.8200	.1020	6.14	.2600	.0090	.49	16,500

Concentrated sewage applied 24 times a week till October 31, afterwards six times a week.
Surface raked about 3 inches deep each week.
November 20, upper foot of sand inverted.
Effluent generally clear and nearly colorless.

Summary of Sixteen Microscopical Examinations of Effluent of Filter Tank No. 28.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Melosira,	6	1.5	25
Cyanophyceæ. Oscillaria,	6	3.	50
Algæ. Ulothrix,	19	67.	750
Fungi. Molds,	6	3.	50

FILTER TANK No. 29.

Week Ending—		Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.		Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.													
May	31,	11,957	58°	-	May	28,	.0376	.0376	4.45	.1600	.0018	.59	21,402
						31,	.0332	.0216	5.22	.0500	.0012	.24	135
June	7,	11,957	61°	-	June	4,	.0405	.0225	5.35	.0100	.0020	.19	28,623
						7,	.0800	.0250	5.93	.0200	.0100	.16	26,280
	14,	11,957	62°	-		11,	.0710	.0240	5.92	.0500	.1000	.23	8,614
						14,	.1050	.0190	5.86	.7500	.0400	.22	2,360
	21,	11,957	64°	-		18,	.0980	.0220	5.95	1.9000	.0300	.16	2,640
						21,	.0420	.0100	6.22	2.5000	.0300	.10	2,640
	28,	11,957	71°	-		25,	.0324	.0116	6.17	2.5000	.0250	.11	63
						28,	.0284	.0104	6.64	1.7500	.0180	.09	24
July	5,	11,957	72°	-	July	2,	.0304	.0124	6.84	1.8500	.0080	.09	-
	12,	10,961	72°	-		9,	.0284	.0156	8.63	2.0000	.0120	.08	-
	19,	11,957	73°	-		16,	.0272	.0112	9.07	1.9000	.0120	.07	-
	26,	19,729	71°	72°		23,	.0108	.0094	9.34	1.5000	.0100	.06	-
Aug.	2,	26,465	73°	78°		30,	.0074	.0188	6.74	1.1500	.0050	.08	-
	9,	27,501	76°	76°	Aug.	6,	.0070	.0164	7.69	1.4000	.0022	.13	380
	16,	27,501	73°	72°		13,	.0026	.0154	9.39	1.1000	.0010	.10	801
	23,	27,501	72°	72°		20,	.0059	.0168	8.37	2.2500	.0014	.09	967
	30,	27,501	67°	71°		27,	.0042	.0190	9.85	1.9000	.0006	.10	238
Sept.	6,	27,501	66°	70°	Sept.	3,	.0046	.0254	6.32	1.7500	.0004	.13	-
	13,	27,501	68°	69°		10,	.0046	.0240	7.02	2.2500	.0012	.13	506
	20,	25,987	66°	69°		17,	.0022	.0172	5.76	1.9000	.0004	.11	-
	27,	27,501	62°	64°		24,	.0048	.0182	7.37	1.6000	.0004	.13	2,520
Oct.	4,	27,501	60°	64°	Oct.	1,	.0070	.0260	6.95	1.4000	.0006	-	6,254
	11,	27,501	59°	58°		8,	.0042	.0234	5.88	1.8000	.0002	.18	32,640
	18,	27,501	54°	57°		15,	.0160	.0246	6.12	1.2500	.0004	.19	78,588
	25,	25,987	50°	50°		22,	.0646	.0518	4.94	1.4000	.0008	.31	14,160
Nov.	1,	27,501	47°	49°		29,	.0416	.0252	6.07	1.0000	.0006	.23	54,398
	8,	27,501	45°	50°	Nov.	5,	.0404	.0324	6.67	1.5300	.0014	.20	1,711
	15,	27,501	45°	48°		12,	.0670	.0410	6.89	1.2700	.0012	.37	31,978
	22,	27,501	42°	46°		19,	.0196	.0408	5.30	1.9900	.0009	.25	24,840
	29,	26,983	40°	47°		26,	.0160	.0506	5.87	1.3100	.0008	.26	11,520
Dec.	6,	27,501	45°	44°	Dec.	3,	.0700	.0290	9.16	1.8100	.0025	.18	16,000

Sewage applied 24 times a week till July 23, afterwards 54 times a week.
Effluent generally slightly turbid.

FILTER TANK NO. 29 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
Dec. 13,	27,501	45°	47°	Dec. 10,	.0328	.0436	5.50	2.2200	.0022	.21	9,540
20,	27,501	45°	44°	17,	.0410	.0380	4.57	1.8500	.0012	.24	4,800
27,	23,436	45°	45°	-	-	-	-	-	-	-	-
1891.											
Jan. 3,	27,501	45°	44°	Jan. 1,	.0900	.0380	4.22	1.5200	.0012	.20	5,220
10,	27,501	45°	44°	8,	.0400	.0284	6.64	1.4600	.0008	.17	2,100
17,	27,501	46°	45°	15,	.0208	.0340	3.84	1.5600	.0010	.20	1,920
24,	26,983	45°	46°	22,	.0360	.0220	4.35	1.6000	.0050	.17	240
31,	22,921	44°	43°	29,	.0540	.0274	4.32	1.7400	.0009	.20	1,160
Feb. 7,	27,501	44°	43°	Feb. 5,	.0316	.0292	4.02	1.7500	.0004	.22	2,940
14,	27,501	44°	43°	12,	.0288	.0258	5.47	1.8300	.0006	.21	1,580
21,	27,501	44°	44°	19,	.0216	.0324	4.02	1.4700	.0006	.22	2,460
28,	27,501	44°	44°	26,	.0074	.0238	4.15	1.5400	.0006	.23	1,120
March 7,	27,501	44°	41°	March 5,	.0425	.0315	3.80	1.1600	.0008	.21	2,640
14,	22,921	44°	45°	12,	.0156	.0130	3.65	1.4800	.0012	.23	1,500
21,	22,921	44°	42°	19,	.1100	.0320	3.40	1.7700	.0012	.25	1,640
28,	7,653	-	44°	-	-	-	-	-	-	-	-
April 4,	27,501	45°	46°	April 2,	.0330	.0316	5.64	1.4700	.0012	.18	106
11,	27,501	44°	45°	9,	.0476	.0280	4.80	1.4600	.0008	.22	4,320
18,	15,225	45°	53°	-	-	-	-	-	-	-	-
25,	27,501	52°	57°	23,	.0236	.0280	6.00	2.4700	.0012	.11	8,280
May 2,	27,501	50°	56°	30,	.0460	.0408	5.72	2.1600	.0007	.22	12,960
9,	27,501	50°	53°	May 7,	.0540	.0440	5.72	1.5000	.0010	.33	4,200
16,	27,501	56°	59°	14,	.0400	.0436	5.44	2.0200	.0006	.23	1,860
23,	27,501	55°	60°	21,	.0260	.0356	9.60	2.2700	.0010	.26	4,560
30,	27,501	60°	63°	28,	.0560	.0600	6.30	1.9300	.0012	.36	12,960
June 6,	27,501	62°	63°	June 4,	.0060	.0280	8.25	2.1100	.0000	.18	22,860
13,	27,501	64°	70°	11,	.0172	.0540	8.78	2.7500	.0028	.45	560
20,	27,501	70°	68°	18,	.0082	.0540	12.22	3.2900	.0006	.48	6,480
27,	27,501	67°	70°	25,	.0198	.1120	10.24	2.7500	.0016	.56	1,080
July 4,	27,501	67°	70°	July 2,	.0068	.0596	9.08	2.7200	.0004	.36	920
11,	26,465	67°	69°	9,	.0132	.0346	9.94	2.5400	.0012	.36	28,320

Sewage applied 54 times a week.
Surface raked about 1 inch deep each week.
Experiments interrupted by high water in the river, January 25, 26, March 14-16, 23-27, April 14 and 15.
Effluent generally slightly turbid.

FILTER TANK No. 29 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
July 18,	27,501	73°	76°	July 16,	.0280	.0700	6.86	3.9400	.0016	.40	28
25,	27,501	73°	72°	23,	.0148	.0604	15.80	3.0700	.0040	.30	340
Aug. 1,	27,501	70°	70°	30,	.0184	.0434	14.60	2.9800	.0016	.50	7,200
8,	27,501	70°	73°	Aug. 6,	.0640	.0680	7.28	2.9400	.0020	.30	12,960
15,	27,501	74°	76°	13,	.0220	.0440	7.28	3.4000	.0010	.35	370
22,	27,501	73°	74°	20,	.0440	.0900	6.80	2.3600	.0250	.44	8,100
29,	27,501	73°	74°	27,	.0200	.0804	8.52	2.4100	.0026	.40	-
Sept. 5,	27,501	68°	68°	Sept. 3,	.0600	.1160	8.82	2.9400	.0036	.60	18,360
12,	27,501	65°	67°	10,	.0320	.1220	8.50	3.1700	.0180	.65	3,880
19,	27,501	67°	71°	17,	.0560	.0620	7.20	2.8100	.0014	.38	80,496
26,	27,501	69°	72°	24,	.0360	.0560	10.21	3.5800	.0022	.32	-
Oct. 3,	27,501	70°	70°	Oct. 1,	.1660	.1560	9.56	4.0000	.0350	.86	5,060
10,	27,501	65°	61°	8,	.1660	.0760	9.88	3.6000	.0006	.48	8,712
17,	27,501	56°	55°	15,	.1800	.0800	8.50	2.6100	.0044	.44	51,800
24,	27,501	51°	53°	22,	.1500	.0620	6.57	2.9500	.0060	.39	8,235
31,	27,501	46°	47°	29,	.2400	.1160	12.44	2.6500	.0100	.59	6,980
Nov. 7,	27,501	45°	48°	Nov. 5,	.1260	.1020	7.63	2.2000	.0040	.55	6,000
14,	27,501	45°	51°	12,	.0840	.0720	9.98	2.0400	.0090	.39	26,000
21,	27,501	46°	50°	19,	.2100	.1040	7.20	2.1500	.0100	.55	8,000
28,	26,465	43°	49°	25,	.2200	.1380	6.32	1.6400	.0600	.68	93,000
Dec. 5,	27,501	40°	47°	Dec. 3,	.5700	.0900	7.08	1.7300	.0044	.42	179,000
12,	27,501	44°	49°	10,	.1300	.0780	6.68	2.4400	.0040	.42	41,000
19,	27,501	45°	45°	17,	.0960	.0840	8.00	2.2100	.0036	.41	200,000
26,	25,469	45°	49°	-	-	-	-	-	-	-	-
				31,	.0560	.0800	7.25	2.0600	.0036	.43	47,000

Sewage applied 54 times a week.
Surface raked about 1 inch deep each week.
Effluent generally slightly turbid and with considerable sediment.

Summary of Sixteen Microscopical Examinations of Effluent.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Melosira,	6	3	50
Unclassified,	6	16	250
Algæ. Ulothrix,	50	165	750
Fungi.			
Molds,	6	3	50
Saccharomyces,	50	2,170	14,000
ANIMALS.			
Rhizopoda. Amœba,	19	88	600
Infusoria.			
Monas,	44	2,840	38,000
Paramæcium,	38	310	2,000
Vorticella,	6	38	600
Vermes.			
Anguillula,	50	225	2,000
Annurea,	12	10	100
Rotifer,	6	25	400
Rotatorian ova,	12	6	50
Miscellaneous. Starch,	6	6	100

Filter Tank No. 30.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
May 31,	47,829	58°	62°	-	May 28,	.0304	.0204	2.82	.2700	.0006	.13	28,743
					31,	.0380	.0204	4.57	.2000	.0012	.10	12
June 7,	47,829	61°	63°	-	June 4,	.0780	.0200	4.82	.2200	.0070	.11	20,580
					7,	.1520	.0280	5.42	.6500	.0120	.09	7
14,	47,829	62°	63°	-	11,	.1600	.0290	4.76	1.5000	.0800	.20	23,268
					14,	.0488	.0116	4.96	2.5000	.0060	.08	1,366
21,	47,829	64°	70°	-	18,	.0120	.0106	4.75	2.0000	.0020	.06	307
					21,	.0056	.0126	5.87	2.4000	.0030	.09	19,980
28,	47,829	71°	72°	-	25,	.0136	.0160	5.75	1.9000	.0014	.08	1,181
					28,	.1020	.0360	5.65	1.3500	.0026	.17	12,685

Sewage applied 6 times a week.
Effluent generally slightly turbid.

FILTER TANK NO. 30 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
July 5,	47,829	72°	74°	-	July 2,	.0610	.0250	5.67	1.8500	.0018	.10	96,120
12,	47,829	72°	73°	-	9,	.0272	.0180	9.30	2.2500	.0020	.10	3,180
19,	47,829	73°	74°	-	16,	.0740	.0240	6.00	2.2500	.0030	.11	-
26,	47,829	71°	70°	-	23,	.0740	.0310	6.13	1.8500	.0036	.14	5,760
Aug. 2,	47,829	73°	77°	-	30,	.0066	.0108	6.31	1.6000	.0004	.07	-
9,	47,829	76°	76°	-	Aug. 6,	.0066	.0116	8.39	1.8500	.0006	.08	23
16,	47,829	73°	72°	-	13,	.0048	.0082	9.92	1.8500	.0004	.08	11,040
23,	47,829	72°	71°	-	20,	.0066	.0134	8.97	2.8000	.0006	.09	31
30,	47,829	67°	70°	-	27,	.0060	.0104	13.02	1.9000	.0002	.08	10
Sept. 6,	47,829	66°	69°	-	Sept. 3,	.0050	.0122	7.64	1.9000	.0002	.06	-
13,	47,829	68°	69°	-	10,	.0044	.0142	7.65	1.5500	.0016	.11	-
20,	47,829	66°	69°	-	17,	.0032	.0106	5.77	2.2000	.0004	.13	-
27,	47,829	62°	63°	-	24,	.0028	.0094	8.91	1.7000	.0002	.09	2
Oct. 4,	47,829	60°	63°	-	Oct. 1,	.0042	.0098	8.28	1.6000	.0001	-	62
11,	47,829	59°	57°	-	8,	.0018	.0100	5.75	1.8500	.0001	.11	15
18,	45,836	54°	56°	-	15,	.0186	.0122	7.40	1.1500	.0012	.14	19,824
25,	13,970	50°	51°	-	23,	.0416	.0080	4.98	1.5000	.0012	.10	59
Nov. 1,	43,843	47°	49°	-	29,	.0495	.0485	6.16	.6500	.0008	.16	2,400
8,	47,829	46°	50°	-	Nov. 5,	.0350	.0120	7.65	1.4000	.0030	.11	61
15,	47,829	45°	47°	-	12,	.0072	.0148	7.12	1.5900	.0016	.09	75
22,	47,829	42°	45°	-	19,	.0046	.0130	5.52	1.5900	.0004	.15	960
29,	47,829	40°	46°	-	26,	.0054	.0132	6.22	1.5100	.0002	.15	130
Dec. 6,	47,829	45°	44°	-	Dec. 3,	.0064	.0158	12.28	2.1000	.0001	.16	920
13,	49,821	45°	46°	-	10,	.0034	.0132	6.22	2.0400	.0002	.12	150
20,	47,829	45°	44°	-	17,	.0030	.0106	4.54	1.7400	.0004	.14	920
27,	43,843	45°	44°	-	-	-	-	-	-	-	-	-
1891.												
Jan. 3,	47,829	45°	44°	-	Jan. 1,	.0110	.0124	4.29	1.6400	.0008	.11	1,040
10,	47,829	45°	44°	-	8,	.0214	.0142	8.65	1.3300	.0028	.11	80
17,	47,829	46°	45°	-	15,	.0060	.0098	3.65	1.2500	.0003	.10	60
24,	45,836	45°	46°	-	22,	.0034	.0116	4.53	1.5800	.0001	.11	80
31,	39,857	44°	43°	-	29,	.0036	.0122	4.10	2.0100	.0003	.10	30

Sewage applied 6 times a week till July 23, afterwards 24 times a week.
Surface raked about 1 inch deep each week, beginning October 28.
Experiments interrupted by high water in the river January 25, 26.
Effluent clear or nearly so.

FILTER TANK NO. 30 — *Continued.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.												
Feb. 7,	47,829	44°	43°	-	Feb. 5,	.0032	.0126	4.20	1.6100	.0000	.11	34
14,	47,829	44°	43°	-	12,	.0042	.0130	6.77	1.9500	.0001	.11	5
21,	47,829	45°	43°	-	19,	.0038	.0120	4.22	1.4300	.0001	.11	6
28,	47,829	44°	44°	-	26,	.0030	.0116	5.34	1.5500	.0002	.13	30
March 7,	47,829	44°	40°	-	March 5,	.0034	.0100	4.20	1.1500	.0000	.11	25
14,	39,857	44°	45°	-	12,	.0022	.0102	3.92	1.5800	.0000	.09	24
21,	39,857	44°	42°	-	19,	.0026	.0100	3.12	2.0000	.0003	.12	124
28,	13,970	-	44°	-	-	-	-	-	-	-	-	-
April 4,	47,829	45°	45°	-	April 2,	.0096	.0115	6.44	1.8000	.0001	.08	0
11,	47,829	44°	45°	-	9,	.0070	.0108	4.73	1.3700	-	-	96
18,	25,907	45°	50°	-	-	-	-	-	-	-	-	-
25,	47,829	52°	57°	-	23,	.0126	.0138	7.35	2.4800	.0014	.07	320
May 2,	47,829	51°	55°	-	30,	.0028	.0118	5.94	2.2900	.0000	.12	840
9,	47,829	50°	52°	-	May 7,	.0110	.0150	6.32	1.9700	.0004	.10	1,480
16,	47,829	56°	59°	-	14,	.0048	.0176	5.82	2.6400	.0004	.13	3,840
23,	47,829	55°	60°	-	21,	.0030	.0112	10.98	2.4900	.0000	.19	760
30,	47,829	60°	63°	-	28,	.0034	.0124	7.12	3.3000	.0014	.14	125
June 6,	47,829	63°	64°	-	June 4,	.0042	.0148	10.08	3.5200	.0002	.14	760
13,	47,829	64°	70°	-	11,	.0042	.0140	8.73	3.7200	.0000	.12	680
20,	47,829	70°	70°	-	18,	.0118	.0198	13.58	4.1700	.0012	.17	4,980
27,	47,829	67°	69°	-	25,	.0194	.0156	9.70	2.8400	.0036	.16	0
July 4,	47,829	67°	70°	-	July 2,	.0480	.0780	8.92	3.5600	.0120	.14	7,560
11,	47,829	67°	69°	-	9,	.0560	.0260	10.52	3.1500	.0100	.15	700
18,	47,829	73°	76°	-	16,	.0556	.0158	6.44	3.7000	.0024	.15	340
25,	47,829	73°	73°	-	23,	.0780	.0180	16.80	4.1200	.0020	.13	1,840
Aug. 1,	47,829	70°	69°	-	30,	.0310	.0142	17.28	3.0500	.0024	.18	820
8,	47,829	70°	72°	-	Aug. 6,	.0488	.0204	5.86	2.2800	.0100	.15	2,720
15,	45,836	74°	76°	-	13,	.1040	.0160	7.03	3.4400	.0030	.14	257
22,	47,829	73°	74°	-	20,	.0480	.0116	6.48	3.0400	.0030	.15	247
29,	47,829	73°	74°	-	27,	.0600	.0160	8.80	2.6800	.0016	.12	626
Sept. 5,	47,829	68°	68°	-	Sept. 3,	.0276	.0110	6.68	2.4000	.0014	.15	1,632
12,	45,836	65°	67°	-	10,	.0204	.0124	11.18	2.5800	.0016	.13	218

Sewage applied 24 times a week.
Surface raked about 1 inch deep each week till April 17, afterwards about 3 inches deep each week.
Experiments interrupted by high water in the river March 14-16, 23-27, April 14, 16.
June 18, a trap was attached to faucet.
Effluent clear or very slightly turbid.

FILTER TANK NO. 30 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
Sept. 19,	47,829	68°	70°	-	Sept. 17,	.0204	.0128	6.62	2.5300	.0012	.12	-
26,	47,829	69°	72°	-	24,	.0332	.0156	10.88	3.8400	.0014	.14	666
Oct. 3,	47,829	70°	69°	-	Oct. 1,	.0640	.0200	13.54	3.2500	.0014	.13	-
10,	47,829	65°	61°	-	8,	.0740	.0180	9.60	3.8900	.0150	.18	1,280
17,	47,829	56°	55°	-	15,	.0520	.0220	9.28	2.6000	.0020	.15	202
24,	47,829	51°	52°	-	22,	.0268	.0128	6.35	3.0600	.0010	.12	420
31,	47,829	46°	50°	-	29,	.1400	.0220	15.78	2.8800	.0030	.15	334
Nov. 7,	47,829	45°	46°	-	Nov. 5,	.5000	.0580	6.90	1.2500	.0180	.54	9,560
14,	47,829	45°	51°	-	12,	.2800	.0360	9.38	1.4000	.0300	.31	14,360
21,	47,829	46°	49°	-	19,	.1440	.0440	7.68	2.7200	.0220	.25	10,000
28,	47,829	43°	49°	-	25,	.1800	.0600	5.98	2.2800	.0300	.37	18,500
Dec. 5,	47,829	40°	47°	2m.	Dec. 3,	.0680	.0400	8.82	1.9300	.0036	.27	36,000
12,	47,829	44°	49°	1½m.	10,	.1260	.0620	6.25	1.7500	.0035	.35	22,800
19,	47,982	45°	45°	1m.	17,	.0440	.0560	8.05	1.9500	.0014	.42	120,000
26,	47,829	45°	49°	-	31,	.0840	.0780	6.17	1.7800	.0030	.61	21,900

Sewage applied 24 times a week till October 31, afterwards 6 times a week.
Surface raked about 3 inches deep each week.
October 9, trap removed from faucet.
Effluent clear or very slightly turbid.

Summary of Sixteen Microscopical Examinations of Effluent.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Navicula,	6	3	50
Pinnularia,	6	3	50
Algæ. Ulothrix,	12	10	100
Fungi.			
Saccharomyces,	6	12	200
Unclassified,	6	30	500
ANIMALS.			
Infusoria. Monas,	19	12	100
Vermes. Rotifer,	6	10	150

Filter Tank No. 31.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
May 31,	47,829	58°	61°	-	May 28,	.0244	.0202	1.62	.0400	.0004	.43	9,048
					31,	.1240	.0340	4.61	.0100	.0004	.19	4,575
June 7,	47,829	61°	61°	-	June 4,	.4200	.0200	5.12	.0200	.0040	.16	2,280
					7,	.8000	.0600	5.70	.0300	.0200	.20	6
14,	47,829	62°	63°	-	11,	1.0500	.0700	4.97	.1100	.2500	.45	481
					14,	1.8000	.1500	5.17	.9000	.5000	.57	23
21,	47,829	64°	70°	-	18,	.9000	.0600	4.67	1.6000	.3500	.45	23
					21,	.2700	.0400	6.02	2.2500	.3500	.49	271
28,	47,829	71°	72°	-	25,	.0448	.0152	4.92	2.2500	.0800	.14	46
					28,	.0146	.0160	5.77	1.7500	.0300	.16	25
July 5,	47,829	72°	74°	-	July 2,	.0104	.0176	5.12	2.5000	.0120	.11	23,380
12,	47,829	72°	73°	-	9,	.0070	.0160	7.68	2.4000	.0012	.11	56
19,	47,829	73°	74°	-	16,	.0046	.0130	5.92	2.3500	.0010	.08	4
26,	47,829	71°	70°	-	23,	.0296	.0104	5.84	1.7500	.0040	.11	114
Aug. 2,	47,829	73°	77°	-	30,	.0084	.0140	5.23	1.7500	.0012	.08	-
9,	47,829	76°	76°	-	Aug. 6,	.0074	.0138	7.30	2.5000	.0012	.11	4
16,	47,829	73°	72°	-	13,	.0076	.0138	10.24	2.3500	.0012	.08	80
23,	47,829	72°	71°	-	20,	.0082	.0162	9.08	2.5000	.0020	.12	50
30,	47,829	67°	70°	-	27,	.0126	.0160	11.02	1.9000	.0060	.11	12
Sept. 6,	43,843	66°	69°	-	Sept. 3,	.0088	.0168	6.22	1.7500	.0012	.13	-
13,	47,829	68°	69°	-	10,	.0156	.0124	7.58	1.5000	.0050	.13	-
20,	45,836	66°	69°	-	17,	.0110	.0110	5.37	1.3500	.0028	.09	-
27,	47,829	62°	63°	-	24,	.0138	.0130	8.86	1.1500	.0032	.14	19
Oct. 4,	23,914	60°	64°	-	Oct. 1,	.0074	.0138	6.66	1.1500	.0020	-	140
11,	0	-	61°	-	-	-	-	-	-	-	-	-
18,	45,836	54°	56°	-	14,	.0088	.0092	8.66	1.3500	.0024	.13	4,320
25,	39,857	50°	50°	-	23,	.0150	.0146	4.68	.7500	.0012	.11	394
Nov. 1,	47,829	47°	49°	-	29,	.0180	.0160	6.35	1.0000	.0018	.24	350
8,	47,829	45°	50°	-	Nov. 5,	.0056	.0168	7.25	1.3400	.0005	.17	50
15,	47,829	45°	47°	-	12,	.0024	.0148	6.08	1.3700	.0006	.16	15
22,	47,829	42°	46°	-	19,	.0028	.0172	5.65	1.3200	.0001	.17	36
29,	47,829	40°	46°	-	26,	.0034	.0160	5.39	1.3700	.0003	.15	11
Dec. 6,	47,829	45°	44°	-	Dec. 3,	.0052	.0152	8.80	1.4300	.0007	.14	8

Sewage applied 6 times a week till July 23, afterwards 24 times a week.
Surface raked about 1 inch deep each week, beginning October 15.
Effluent clear or nearly so.

FILTER TANK No. 31 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Dec. 13,	47,829	45°	46°	-	Dec. 10,	.0042	.0120	5.47	2.1600	.0004	.12	13
20,	47,829	45°	44°	-	17,	.0020	.0130	4.70	1.6800	.0005	.17	2
27,	43,843	45°	45°	-	-	-	-	-	-	-	-	-
1891.												
Jan. 3,	47,829	45°	44°	-	Jan. 1,	.0130	.0112	4.55	1.7300	.0003	.14	5
10,	47,829	45°	44°	-	8,	.0044	.0144	13.22	1.7400	.0001	.14	6
17,	47,829	46°	45°	-	15,	.0018	.0126	3.30	1.4900	.0001	.09	32
24,	45,836	45°	46°	-	22,	.0022	.0106	4.51	1.6600	.0004	.10	7
31,	39,857	44°	43°	-	29,	.0266	.0138	3.90	1.8600	.0003	.09	21
Feb. 7,	47,829	44°	43°	-	Feb. 5,	.0060	.0150	4.50	2.0100	.0007	.13	4
14,	47,829	44°	43°	-	12,	.0100	.0140	7.58	2.0000	.0028	.16	3
21,	47,829	44°	44°	-	19,	.0034	.0130	4.90	1.9500	.0002	.15	6
28,	47,829	44°	45°	-	26,	.0032	.0138	6.23	1.8100	.0005	.13	-
March 7,	47,829	44°	41°	-	March 5,	.0038	.0110	4.35	1.2600	.0001	.11	6
14,	39,853	44°	45°	-	12,	.0044	.0124	4.57	1.9500	.0002	.14	8
21,	39,853	44°	43°	-	19,	.0072	.0098	2.95	1.8000	.0004	.13	18
28,	13,970	-	44°	-	-	-	-	-	-	-	-	-
April 4,	47,829	45°	45°	-	April 2,	.0066	.0120	5.02	1.9400	.0006	.12	12
11,	47,829	44°	45°	-	9,	.0056	.0132	4.15	1.5700	.0005	.12	15
18,	25,907	45°	49°	-	-	-	-	-	-	-	-	-
25,	47,829	52°	56°	-	23,	.0096	.0154	7.60	2.5400	.0012	.10	11
May 2,	47,829	51°	55°	-	30,	.0026	.0138	7.47	2.2900	.0003	.12	12
9,	47,829	50°	53°	-	May 7,	.0034	.0112	7.04	1.9200	.0004	.14	3
16,	47,829	56°	60°	-	14,	.0048	.0156	5.91	2.1400	.0004	.15	5
23,	47,829	55°	60°	-	21,	.0048	.0130	9.40	2.3500	.0000	.16	30
30,	47,829	60°	63°	-	28,	.0052	.0150	8.26	3.5000	.0006	.15	10
June 6,	47,829	63°	64°	-	June 4,	.0066	.0152	11.78	3.3800	.0002	.15	4
13,	47,829	64°	70°	-	11,	.0068	.0134	9.61	2.4500	.0000	.13	14
20,	47,829	70°	68°	-	18,	.0036	.0200	16.00	4.0800	.0006	.16	2
27,	47,829	67°	70°	-	25,	.0076	.0124	8.62	2.8500	.0002	.17	0
July 4,	47,829	67°	70°	-	July 2,	.0062	.0142	8.82	2.7200	.0001	.15	0
11,	47,829	67°	70°	-	9,	.0062	.0148	12.00	3.7300	.0012	.15	4

Sewage applied 24 times a week.
Surface raked about 1 inch deep each week till April 17, afterwards about 3 inches deep each week.
Experiments interrupted by high water in the river January 25, 26, March 14-16, 23-27, April 14-16.
Effluent clear and practically colorless.

FILTER TANK NO. 31 — *Concluded.*

WEEK ENDING —	Quantity Applied. — Gallons per Acre Daily.	TEMPERATURE. Sewage.	TEMPERATURE. Effluent.	Sewage remained on Surface.	Date of Sample.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
July 18,	47,829	73°	76°	-	July 16,	.0250	.0154	6.40	4.3800	.0024	.17	2
25,	47,829	73°	73°	-	23,	.0490	.0214	15.45	3.9200	.0003	.14	-
Aug. 1,	47,829	70°	69°	-	30,	.2200	.0200	19.02	2.2200	.0005	.17	1,365
8,	47,829	70°	73°	-	Aug. 6,	.0740	.0160	6.00	4.1300	.0002	.13	1,050
15,	45,836	74°	77°	-	13,	.0660	.0400	7.52	3.1200	.0003	.18	182
22,	47,829	73°	75°	-	20,	.0640	.0280	6.48	3.1600	.0003	.16	-
29,	47,829	73°	74°	-	27,	.0368	.0192	9.20	2.4900	.0002	.16	402
Sept. 5,	47,829	68°	68°	-	Sept. 3,	.0228	.0140	7.68	2.5000	.0002	.18	190
12,	45,836	65°	68°	-	10,	.0152	.0162	11.28	3.2900	.0004	.14	102
19,	47,829	68°	70°	-	17,	.0174	.0150	6.88	2.5400	.0006	.11	1,340
26,	47,829	69°	72°	-	24,	.0218	.0226	12.30	3.9400	.0002	.18	210
Oct. 3,	47,829	70°	69°	-	Oct. 1,	.0192	.0160	10.46	3.6300	.0004	.14	-
10,	47,829	65°	61°	-	8,	.0496	.0176	9.95	3.7000	.0002	.20	294
17,	47,829	56°	55°	-	15,	.0720	.0200	10.02	2.8000	.0002	.14	222
24,	47,829	51°	53°	-	22,	.0214	.0160	6.65	2.8400	.0010	.13	64
31,	47,829	46°	50°	-	29,	.2000	.0200	16.50	3.0000	.0010	.16	68
Nov. 7,	47,829	45°	46°	-	Nov. 5,	.2900	.0400	6.38	2.0900	.0014	.28	7,000
14,	47,829	45°	51°	-	12,	.1900	.0300	8.90	2.1700	.0150	.29	36,500
21,	47,829	46°	49°	-	19,	.1440	.0500	6.91	2.6100	.0070	.35	25,000
28,	47,829	43°	48°	-	25,	.0960	.0820	6.13	2.4600	.0110	.26	49,000
Dec. 5,	47,829	40°	46°	10m.	Dec. 3,	.1060	.0300	12.63	2.2500	.0007	.22	2,500
12,	47,829	44°	49°	4m.	10,	.0360	.0260	6.53	2.8300	.0006	.23	2,100
19,	47,829	45°	45°	3½m.	17,	.0154	.0244	8.13	2.4200	.0001	.24	2,100
26,	47,829	45°	48°	-	-	-	-	-	-	-	-	-
					31,	.0320	.0246	6.92	2.5200	.0004	.24	6,000

Sewage applied 24 times a week till October 31, afterwards 6 times a week.
Surface raked about 3 inches deep each week.
Effluent clear and practically colorless.

Summary of Fifteen Microscopical Examinations of Effluent.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Melosira,	7	20	300
Synedra,	7	3.3	50
Fungi. Molds,	13	6.6	50
ANIMALS.			
Infusoria. Monas,	7	27	400
Vermes.			
Anguillula,	7	3.3	50
Rotatorian ova,	7	6.6	100

FILTRATION OF WATER.

The experiments upon the intermittent filtration of water described in the special report upon the Purification of Sewage and Water (pages 601 and 695) have been continued with most satisfactory results.

The prevalence of an excessive amount of typhoid fever among the users of some of the public water supplies of the State, and the conclusive evidence that, in some cases at least, the water was the means of carrying the germs of that disease,* have given a new impetus to the study of water filtration.

Our attention has been specially directed toward the bacteria. In sewage purification the removal of the organic matters capable of putrefaction is often of the greatest importance; but in the filtration of sewage-polluted water — water capable of causing disease if it is not filtered — the removal of the germs of disease is the all-important point. The effluents from the tanks filtering water have invariably been well purified as far as chemical constituents are concerned; color has been much reduced or entirely removed, according to the rate of filtration, the amount of water which had previously passed through the filter and other conditions; and the organic matters have been so reduced as to be unobjectionable in amount.

As a result of a very careful study of the conditions of taking samples and of determinations of the numbers of the various species of bacteria in the effluent of Filter Tank No. 8 and in the applied water, the results of which will be found in the report of the biological work, which follows, it was found that if any bacteria passed the number must be very small, — at least as low as one in a thousand.

* Annual Report, 1890, page 525; also a Report upon the Sanitary Condition of the Wate Supply of Lowell, Mass., by Prof. W. T. Sedgwick, to the Lowell Water Board, Lowell, Mass., 1891.

The best proof that none pass was given by applying Merrimack River water taken directly from the canal, instead of the city water, commencing Nov. 13, 1891. The city water, which had been applied during the four years in which this filter had been in use, is also taken from the Merrimack River; but, in passing through the capacious reservoir and some miles of pipe, requiring in all probably two weeks to pass from the river to the Experiment Station, the greater number of bacteria die. While the city water has about a hundred bacteria per cubic centimeter, the canal water contains from one thousand to fifteen thousand. If the small number of bacteria found in the effluent of Filter No. 8 had come through the filter, we should have expected that on applying the canal water the number would have increased in somewhat the same ratio as the increase in the numbers applied. The actual result, however, was that no more, in fact hardly as many, were found after making the change.

The average number of bacteria for six weeks, from November 15 to December 26, was as follows: —

	Bacteria per Cubic Centimeter.
Water applied,	2,989
Effluent,	0.91

This shows a removal of 99.97 per cent., and we have strong evidence that those which occasionally appear are due to accidental contamination, or grow in the underdrains. It is thus satisfactorily established that Filter No. 8 purifies the Merrimack River water to such an extent that it is in every way suitable for drinking; it is made colorless and its bacteria are removed.

The one objection to the application of filters like this to the purification of water on a large scale is the low rate of filtration. Owing to the fineness of the loam layer, eight inches thick and six inches below the surface, not more than 300,000 gallons of water per acre daily can be filtered without keeping the surface continually covered.

Filter No. 18 A of No. 1 sand, also filtering canal water, but at a rate of a million gallons per acre daily, has at times removed a very

large percentage of the bacteria, the result for two weeks, December 7 to 20, being: —

	Bacteria per Cubic Centimeter.
Water applied,	4,800
Effluent,	15

showing a removal of 99.7 per cent. The results have been, however, somewhat variable, and it does not seem probable that a filter of so coarse material could be so managed as to always secure the removal of objectionable germs from sewage-polluted water. It seemed probable, however, that filters could be constructed of material in size somewhere between that of No. 8 and of No. 18 A which would allow the passage of more water than No. 8, and at the same time secure the removal of all pathogenic germs.

Four new filters, Nos. 33 to 36, were started in December, 1891, filled with materials nearly like those used in Filter No. 8, but with the loam layer only two inches thick, instead of eight inches. The quantity of water which would pass these filters was unsatisfactory, and after a week's use one-half the loam was removed. Following this change, two of the filters to which water was applied continuously gave rates of from one and one-half to two million gallons per acre daily, while the other two, used intermittently, gave somewhat lower rates. After a month, however, the rates of all the filters were between 450,000 and 500,000 gallons, and at the end of two months all were below 400,000 gallons per acre daily. As the clogging which limited the rate of flow was below the surface, presumably in the loam one foot below the top of the sand, disturbing or scraping the surface did not increase the rates. It was subsequently found, on digging out the filtering material, that the sand had been stratified during the construction of the filter by throwing into water, and was not capable of passing so much water as it otherwise might have done.

By a long series of bacterial examinations upon two of the filters, Nos. 35 and 36, it was determined that germs of typhoid fever added with the applied water were unable to pass these filters. The small and decreasing quantity of water which passed the filters,

FILTER TANK No. 30 — *Concluded.*

Week Ending —	Quantity Applied. — Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
Sept. 19,	47,829	68°	70°	-	Sept. 17,	.0204	.0128	6.62	2.5300	.0012	.12	-
26,	47,829	69°	72°	-	24,	.0332	.0156	10.88	3.8400	.0014	.14	666
Oct. 3,	47,829	70°	69°	-	Oct. 1,	.0640	.0200	13.54	3.2500	.0014	.13	-
10,	47,829	65°	61°	-	8,	.0740	.0180	9.60	3.8900	.0150	.18	1,280
17,	47,829	56°	55°	-	15,	.0520	.0220	9.28	2.6000	.0020	.15	202
24,	47,829	51°	52°	-	22,	.0268	.0128	6.35	3.0600	.0010	.12	420
31,	47,829	46°	50°	-	29,	.1400	.0220	15.78	2.8800	.0030	.15	334
Nov. 7,	47,829	45°	46°	-	Nov. 5,	.5000	.0580	6.90	1.2500	.0180	.54	9,560
14,	47,829	45°	51°	-	12,	.2800	.0360	9.38	1.4000	.0300	.31	14,360
21,	47,829	46°	49°	-	19,	.1440	.0440	7.68	2.7200	.0220	.25	10,000
28,	47,829	43°	49°	-	25,	.1800	.0600	5.98	2.2800	.0300	.37	13,500
Dec. 5,	47,829	40°	47°	2m.	Dec. 3,	.0680	.0400	8.82	1.9300	.0036	.27	36,000
12,	47,829	44°	49°	1½m.	10,	.1260	.0620	6.25	1.7500	.0035	.35	22,800
19,	47,982	45°	45°	1m.	17,	.0440	.0560	8.05	1.9500	.0014	.42	120,000
26,	47,829	45°	49°	-	31,	.0840	.0780	6.17	1.7800	.0030	.61	21,900

Sewage applied 24 times a week till October 31, afterwards 6 times a week.
Surface raked about 3 inches deep each week.
October 9, trap removed from faucet.
Effluent clear or very slightly turbid.

Summary of Sixteen Microscopical Examinations of Effluent.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ.			
Navicula,	6	3	50
Pinnularia,	6	3	50
Algæ. Ulothrix,	12	10	100
Fungi.			
Saccharomyces,	6	12	200
Unclassified,	6	30	500
ANIMALS.			
Infusoria. Monas,	19	12	100
Vermes. Rotifer,	6	10	150

Filter Tank No. 31.

Week Ending—	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Sewage remained on Surface.	Date of Sample.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Free.	Albuminoid.		Nitrates.	Nitrites.		
1890.												
May 31,	47,829	58°	61°	-	May 28,	.0244	.0202	1.62	.0400	.0004	.43	9,048
					31,	.1240	.0340	4.61	.0100	.0004	.19	4,575
June 7,	47,829	61°	61°	-	June 4,	.4200	.0200	5.12	.0200	.0040	.16	2,280
					7,	.8000	.0600	5.70	.0300	.0200	.20	6
14,	47,829	62°	63°	-	11,	1.0500	.0700	4.97	.1100	.2500	.45	481
					14,	1.8000	.1500	5.17	.9000	.5000	.57	23
21,	47,829	64°	70°	-	18,	.9000	.0600	4.67	1.6000	.3500	.45	23
					21,	.2700	.0400	6.02	2.2500	.3500	.49	271
28,	47,829	71°	72°	-	25,	.0448	.0152	4.92	2.2500	.0300	.14	46
					28,	.0146	.0160	5.77	1.7500	.0300	.16	25
July 5,	47,829	72°	74°	-	July 2,	.0104	.0176	5.12	2.5000	.0120	.11	23,380
12,	47,829	72°	73°	-	9,	.0070	.0160	7.68	2.4000	.0012	.11	56
19,	47,829	73°	74°	-	16,	.0046	.0130	5.92	2.3500	.0010	.08	4
26,	47,829	71°	70°	-	23,	.0296	.0104	5.84	1.7500	.0040	.11	114
Aug. 2,	47,829	73°	77°	-	30,	.0084	.0140	5.23	1.7500	.0012	.08	-
9,	47,829	76°	76°	-	Aug. 6,	.0074	.0138	7.30	2.5000	.0012	.11	4
16,	47,829	73°	72°	-	13,	.0076	.0138	10.24	2.3500	.0012	.08	80
23,	47,829	72°	71°	-	20,	.0082	.0162	9.08	2.5000	.0020	.12	50
30,	47,829	67°	70°	-	27,	.0126	.0160	11.02	1.9000	.0060	.11	12
Sept. 6,	43,843	66°	69°	-	Sept. 3,	.0088	.0168	6.22	1.7500	.0012	.13	-
13,	47,829	68°	69°	-	10,	.0156	.0124	7.58	1.5000	.0050	.13	-
20,	45,836	66°	69°	-	17,	.0110	.0110	5.37	1.3500	.0028	.09	-
27,	47,829	62°	63°	-	24,	.0138	.0130	8.86	1.1500	.0032	.14	19
Oct. 4,	23,914	60°	64°	-	Oct. 1,	.0074	.0138	6.66	1.1500	.0020	-	140
11,	0	-	61°	-	-	-	-	-	-	-	-	-
18,	45,836	54°	56°	-	14,	.0088	.0092	8.66	1.3500	.0024	.13	4,320
25,	39,857	50°	50°	-	23,	.0150	.0146	4.68	.7500	.0012	.11	394
Nov. 1,	47,829	47°	49°	-	29,	.0180	.0160	6.35	1.0000	.0018	.24	350
8,	47,829	45°	50°	-	Nov. 5,	.0056	.0168	7.25	1.3400	.0005	.17	50
15,	47,829	45°	47°	-	12,	.0024	.0148	6.08	1.3700	.0006	.16	15
22,	47,829	42°	46°	-	19,	.0028	.0172	5.65	1.3200	.0001	.17	36
29,	47,829	40°	46°	-	26,	.0034	.0160	5.39	1.3700	.0003	.15	11
Dec. 6,	47,829	45°	44°	-	Dec. 3,	.0052	.0152	8.80	1.4300	.0007	.14	8

Sewage applied 6 times a week till July 23, afterwards 24 times a week.
Surface raked about 1 inch deep each week, beginning October 15.
Effluent clear or nearly so.

FILTER TANK NO. 31 — *Continued.*

Week Ending —	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.												
Dec. 13,	47,829	45°	46°	-	Dec. 10,	.0042	.0120	5.47	2.1600	.0004	.12	13
20,	47,829	45°	44°	-	17,	.0020	.0130	4.70	1.6800	.0005	.17	2
27,	43,843	45°	45°	-	-	-	-	-	-	-	-	-
1891.												
Jan. 3,	47,829	45°	44°	-	Jan. 1,	.0130	.0112	4.55	1.7300	.0003	.14	5
10,	47,829	45°	44°	-	8,	.0044	.0144	13.22	1.7400	.0001	.14	6
17,	47,829	46°	45°	-	15,	.0018	.0126	3.30	1.4900	.0001	.09	32
24,	45,836	45°	46°	-	22,	.0022	.0106	4.51	1.6600	.0004	.10	7
31,	39,857	44°	43°	-	29,	.0266	.0138	3.90	1.8600	.0003	.09	21
Feb. 7,	47,829	44°	43°	-	Feb. 5,	.0060	.0150	4.50	2.0100	.0007	.13	4
14,	47,829	44°	43°	-	12,	.0100	.0140	7.58	2.0000	.0028	.16	3
21,	47,829	44°	44°	-	19,	.0034	.0130	4.90	1.9500	.0002	.15	6
28,	47,829	44°	45°	-	26,	.0032	.0138	6.23	1.8100	.0005	.13	-
March 7,	47,829	44°	41°	-	March 5,	.0038	.0110	4.35	1.2600	.0001	.11	6
14,	39,853	44°	45°	-	12,	.0044	.0124	4.57	1.9500	.0002	.14	8
21,	39,853	44°	43°	-	19,	.0072	.0098	2.95	1.8000	.0004	.13	18
28,	13,970	-	44°	-	-	-	-	-	-	-	-	-
April 4,	47,829	45°	45°	-	April 2,	.0066	.0120	5.02	1.9400	.0006	.12	12
11,	47,829	44°	45°	-	9,	.0056	.0132	4.15	1.5700	.0005	.12	15
18,	25,907	45°	49°	-	-	-	-	-	-	-	-	-
25,	47,829	52°	56°	-	23,	.0096	.0154	7.60	2.5400	.0012	.10	11
May 2,	47,829	51°	55°	-	30,	.0026	.0138	7.47	2.2900	.0003	.12	12
9,	47,829	50°	53°	-	May 7,	.0034	.0112	7.04	1.9200	.0004	.14	3
16,	47,829	56°	60°	-	14,	.0048	.0156	5.91	2.1400	.0004	.15	5
23,	47,829	55°	60°	-	21,	.0048	.0130	9.40	2.3500	.0000	.16	30
30,	47,829	60°	63°	-	28,	.0052	.0150	8.26	3.5000	.0006	.15	10
June 6,	47,829	63°	64°	-	June 4,	.0066	.0152	11.78	3.3800	.0002	.15	4
13,	47,829	64°	70°	-	11,	.0068	.0134	9.61	2.4500	.0000	.13	14
20,	47,829	70°	68°	-	18,	.0036	.0200	16.00	4.0800	.0006	.16	2
27,	47,829	67°	70°	-	25,	.0076	.0124	8.62	2.8500	.0002	.17	0
July 4,	47,829	67°	70°	-	July 2,	.0062	.0142	8.82	2.7200	.0001	.15	0
11,	47,829	67°	70°	-	9,	.0062	.0148	12.00	3.7300	.0012	.15	4

Sewage applied 24 times a week.
Surface raked about 1 inch deep each week till April 17, afterwards about 3 inches deep each week.
Experiments interrupted by high water in the river January 25, 26, March 14-16, 23-27, April 14-16.
Effluent clear and practically colorless.

FILTER TANK NO. 31 — *Concluded.*

Week Ending—	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Sewage remained on Surface.	Date of Sample.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.												
July 18,	47,829	73°	76°	-	July 16,	.0250	.0154	6.40	4.3800	.0024	.17	2
25,	47,829	73°	73°	-	23,	.0490	.0214	15.45	3.9200	.0008	.14	-
Aug. 1,	47,829	70°	69°	-	30,	.2200	.0200	19.02	2.2200	.0005	.17	1,365
8,	47,829	70°	73°	-	Aug. 6,	.0740	.0160	6.00	4.1300	.0002	.13	1,050
15,	45,836	74°	77°	-	13,	.0660	.0400	7.52	3.1200	.0003	.18	182
22,	47,829	73°	75°	-	20,	.0640	.0280	6.48	3.1600	.0003	.16	-
29,	47,829	73°	74°	-	27,	.0368	.0192	9.20	2.4900	.0002	.16	402
Sept. 5,	47,829	68°	68°	-	Sept. 3,	.0228	.0140	7.68	2.5000	.0002	.18	190
12,	45,836	65°	68°	-	10,	.0152	.0162	11.28	3.2900	.0004	.14	102
19,	47,829	68°	70°	-	17,	.0174	.0150	6.88	2.5400	.0006	.11	1,340
26,	47,829	69°	72°	-	24,	.0218	.0226	12.30	3.9400	.0002	.18	210
Oct. 3,	47,829	70°	69°	-	Oct. 1,	.0192	.0160	10.46	3.6300	.0004	.14	-
10,	47,829	65°	61°	-	8,	.0496	.0176	9.95	3.7000	.0002	.20	294
17,	47,829	56°	55°	-	15,	.0720	.0200	10.02	2.8000	.0002	.14	222
24,	47,829	51°	53°	-	22,	.0214	.0160	6.65	2.8400	.0010	.13	64
31,	47,829	46°	50°	-	29,	.2000	.0200	16.50	3.0000	.0010	.16	68
Nov. 7,	47,829	45°	46°	-	Nov. 5,	.2900	.0400	6.38	2.0900	.0014	.28	7,000
14,	47,829	45°	51°	-	12,	.1900	.0300	8.90	2.1700	.0150	.29	36,500
21,	47,829	46°	49°	-	19,	.1440	.0500	6.91	2.6100	.0070	.35	25,000
28,	47,829	43°	48°	-	25,	.0960	.0820	6.13	2.4600	.0110	.26	49,000
Dec. 5,	47,829	40°	46°	10m.	Dec. 3,	.1060	.0300	12.63	2.2500	.0007	.22	2,500
12,	47,829	44°	49°	4m.	10,	.0360	.0260	6.53	2.8300	.0006	.23	2,100
19,	47,829	45°	45°	3½m.	17,	.0154	.0244	8.13	2.4200	.0001	.24	2,100
26,	47,829	45°	48°	-	-	-	-	-	-	-	-	-
					31,	.0320	.0246	6.92	2.5200	.0004	.24	6,000

Sewage applied 24 times a week till October 31, afterwards 6 times a week.
Surface raked about 3 inches deep each week.
Effluent clear and practically colorless.

FILTER TANKS Nos. 8, 18 A AND 20 A.

The earlier histories of these filters were given in the special report upon the Purification of Sewage and Water, pages 602, 658 and 695. Filter No. 8 is filled with No. 6 sand, with a layer of loam eight inches thick, the top of which is six inches below the surface; No. 18 A is filled with No. 1 sand; and No. 20 A with No. 1 sand, with a layer of No. 2 sand one foot thick, the top of which is three feet below the surface. The mechanical analyses of the sands were given on page 429. Filter No. 8 has continued to give from the Merrimack River water (city water until Nov. 12, 1891, and afterward canal water) an effluent which compares favorably with the best spring waters, being practically colorless and free from objectionable organic matters and bacteria.

Filter No. 18 A in 1890 received city water at an average rate of 819,000 gallons per acre daily, applied in hourly doses for fourteen hours in the day, and six days in the week. In October the effluent commenced to be colored, and during November no water was applied. In December water was again applied as before, but the color of the effluent was not lower than before the rest. During 1891 water was applied in smaller doses, each equivalent to 5,000 gallons per acre, aggregating as nearly as possible a million gallons per acre daily. The single doses followed each other with intervals of only about seven minutes, days, nights and Sundays. Commencing Aug. 18, 1891, canal water was applied instead of city water.

Filter No. 20 A received city water during the entire time. In the latter part of 1890 the fine No. 2 sand three feet below the surface became clogged, so that water stood in the coarse sand, making the filtration practically continuous. On December 23 a small reservoir with a siphon was provided, which delivered a dose of water equivalent to only 10,000 gallons per acre, and doses were applied as frequently as possible, without causing water to remain standing in the coarse sand.

The average results obtained from these filters, by periods, from the times when water was first applied to them, are shown in the following tables: —

Average Results, by Periods, from Filter Tank No. 8.

		Quantity of Effluent. — Gallons per Acre Daily.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January—December, 1888,	City water,	-	.23	.0017	.0113	.22	.0195	.0000	-	129
	Effluent,	111,180	.00	.0007	.0032	.23	.0269	.0000	-	29
January—December, 1889,	City water,	-	.25	.0009	.0121	.20	.0171	.0000	-	39
	Effluent,	254,130	.00	.0004	.0049	.19	.0244	.0000	-	15
January—December, 1890,	City water,	-	.28	.0017	.0124	.17	.0188	.0000	.32	173
	Effluent,	199,660	.02	.0007	.0057	.17	.0240	.0000	.09	58
January—November 15, 1891,	City water,	-	.21	.0023	.0107	.20	.0222	.0000	.25	141
	Effluent,	187,800	.04	.0006	.0039	.21	.0307	.0000	.07	5
November 15—December 31, 1891,	Canal water,	-	.30	.0057	.0164	.21	.0168	.0003	.47	2,660
	Effluent,	133,950	.03	.0002	.0037	.25	.0272	.0000	.08	1

Average Results, by Periods, from Filter Tank No. 18 A.

February—October and December, 1890.	City water,	-	.27	.0017	.0126	.17	.0195	.0000	.32	188
	Effluent,	819,474	.02	.0012	.0066	.17	.0223	.0000	.12	106
January—August, 1891,	City water,	-	.22	.0024	.0103	.17	.0203	.0000	.27	116
	Effluent,	898,024	.12	.0005	.0058	.17	.0223	.0000	.17	15
September—December, 1891,	Canal water,	-	.23	.0076	.0158	.25	.0138	.0007	.30	4,244
	Effluent,	1,249,180	.14	.0007	.0080	.26	.0290	.0000	.18	81

Average Results, by Periods, from Filter Tank No 20 A.

January—December, 1890,	City water,	-	.28	.0017	.0124	.17	.0188	.0000	.32	173
	Effluent,	587,671	.14	.0011	.0079	.18	.0229	.0000	.19	18
January—December, 1891,	City water,	-	.21	.0024	.0109	.20	.0228	.0000	.26	162
	Effluent,	288,219	.10	.0006	.0056	.20	.0286	.0000	.14	15

The following table contains the analyses of the city water used for filtration in 1891. The earlier analyses, from Nov. 17, 1887, to Dec. 31, 1889, were given in the special report upon the Purification of Sewage and Water, page 618, and from June, 1889, to Dec. 31, 1890, in the annual report for 1890, page 170.

Weekly Analyses of City Water as drawn at the Lawrence Experiment Station.

DATE.	Temperature.	Turbidity.	Sediment.	Color.	AMMONIA. Free.	AMMONIA. Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	NITROGEN AS Nitrites.	Oxygen Consumed.	Dissolved Oxygen.	Oxygen required for Saturation.	Bacteria per Cubic Centimeter.
1891.													
Jan. 7,	38°	V. slight,	0	.23	.0044	.0112	.22	.0180	.0001	.33	1.24	1.30	117
14,	37°	V. slight,	0	.24	.0042	.0134	.20	.0230	.0000	.30	1.23	1.32	104
21,	37°	V. slight,	V. slight,	.24	.0048	.0108	.18	.0210	.0001	.33	1.24	1.32	5
28,	38°	V. slight,	0	.25	.0068	.0120	.15	.0230	.0001	.39	1.20	1.32	60
Feb. 4,	37°	V. slight,	0	.25	.0034	.0114	.14	.0210	.0000	.36	1.29	1.34	21
11,	36°	V. slight,	V. slight,	.27	.0024	.0104	.15	.0180	.0001	.33	1.34	1.35	36
18,	37°	0	0	.25	.0030	.0100	.17	.0210	.0004	.33	1.29	1.33	40
25,	37°	0	0	.25	.0018	.0086	.15	.0170	.0001	.31	1.24	1.31	37
March 4,	36°	0	0	.23	.0018	.0096	.17	.0150	.0000	.29	1.23	1.34	30
11,	37°	V. slight,	0	.23	.0020	.0080	.14	.0160	.0000	.28	1.21	1.38	-
18,	37°	V. slight,	0	.23	.0028	.0080	.13	.0170	.0000	.28	1.24	1.33	36
25,	38°	Slight,	0	.22	.0028	.0062	.16	.0230	.0001	.23	1.22	1.30	-
April 1,	38°	V. slight,	0	.20	.0040	.0070	.15	.0190	.0000	.23	1.22	1.30	15
8,	38°	V. slight,	V. slight,	.18	.0042	.0072	.16	.0260	.0000	.19	1.15	1.28	120
15,	41°	V. slight,	0	.20	.0064	.0070	.16	.0170	.0000	.18	1.15	1.24	31
22,	44°	0	0	.20	-	.0076	.14	.0240	.0000	.22	1.05	1.22	44
29,	48°	0	0	.20	.0006	.0092	.15	.0290	.0000	.30	.93	1.17	98
May 6,	49°	0	0	.20	.0012	.0080	.14	.0200	.0000	.26	.96	1.14	38
13,	51°	0	0	.22	.0018	.0100	.15	.0230	.0000	.22	.94	1.10	74
20,	52°	0	0	.19	.0030	.0086	.13	.0180	.0000	.27	.85	1.08	51
27,	54°	0	0	.22	.0008	.0094	.15	.0220	.0000	.31	.61	1.06	35
June 3,	57°	0	0	.20	.0014	.0096	.16	.0200	.0000	.26	.66	1.04	64
10,	58°	0	0	.21	.0008	.0096	.17	.0180	.0002	.24	.70	1.01	924
17,	62°	0	0	.26	.0010	.0102	.16	.0180	.0000	.31	.55	.96	71
24,	63°	0	V. slight,	.23	.0006	.0120	.15	.0210	.0000	.29	.56	.95	150
July 1,	64°	0	0	.24	.0014	.0132	.19	.0200	.0000	.30	.58	.95	146
8,	65°	0	0	.27	.0016	.0132	.19	.0190	.0000	.28	.54	.93	-
15,	67°	V. slight,	0	.21	.0024	.0112	.22	.0230	.0000	.28	.49	.91	160

Weekly Analyses of City Water as drawn at the Lawrence Experiment Station — Concluded.

Date.		Temperature.	Turbidity.	Sediment.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Dissolved Oxygen.	Oxygen required for Saturation.	Bacteria per Cubic Centimeter.
1891.														
July	22,	70°	V. slight,	0	.25	.0012	.0122	.21	.0130	.0000	.27	.43	.88	168
	29,	69°	0	0	.22	.0006	.0152	.22	.0210	.0001	.24	.48	.88	282
Aug.	5,	68°	0	0	.21	.0012	.0130	.22	.0200	.0001	.21	.53	.90	264
	12,	70°	0	0	.22	.0010	.0136	.22	.0170	.0000	.19	.52	.82	291
	19,	70°	V. slight,	0	.16	.0018	.0116	.23	.0260	.0001	.19	.42	.87	34
	26,	71°	0	0	.17	.0014	.0116	.20	.0250	.0001	.18	.48	.87	136
Sept.	2,	70°	0	0	.15	.0020	.0114	.19	.0280	.0002	.23	.54	.89	376
	9,	67°	V. slight,	V. slight,	.18	.0016	.0090	.19	.0240	.0003	.22	.62	.90	106
	16,	66°	0	V. slight,	.18	.0016	.0122	.18	.0210	.0000	.21	.75	.92	100
	23,	67°	0	0	.18	.0012	.0108	.23	.0280	.0000	.24	.54	.91	64
	30,	68°	0	V. slight,	.19	.0028	.0134	.24	.0300	.0001	.23	.47	.90	74
Oct.	7,	66°	V. slight,	0	.17	.0022	.0144	.28	.0290	.0002	.21	.55	.92	265
	14,	62°	0	0	.17	.0010	.0122	.30	.0310	.0001	.21	.70	.96	390
	21,	57°	0	0	.14	.0018	.0094	.29	.0280	.0002	.17	.74	1.00	390
	28,	53°	0	V. slight,	.16	.0022	.0112	.28	.0280	.0000	.18	.83	1.06	378
Nov.	4,	53°	V. slight,	0	.17	.0026	.0092	.28	.0250	.0000	.22	.93	1.10	344
	11,	47°	0	V. slight,	.15	.0030	.0130	.27	.0260	.0001	.20	.93	1.11	52
	18,	50°	V. slight,	0	.18	.0026	.0140	.30	.0270	.0006	.23	.93	1.11	28
	25,	48°	V. slight,	V. slight,	.21	.0032	.0132	.25	.0290	.0002	.24	.94	1.15	66
Dec.	2,	45°	V. slight,	0	.24	.0022	.0124	.24	.0340	.0001	.33	1.07	1.19	159
	9,	43°	V. slight,	V. slight,	.25	.0028	.0138	.25	.0260	.0002	.40	1.14	1.21	38
	16,	42°	V. slight,	V. slight,	.28	.0034	.0148	.21	.0330	.0002	.41	1.16	1.22	330
	23,	41°	V. slight,	V. slight,	.27	.0030	.0136	.24	.0320	.0002	.39	1.15	1.24	1,320
	30,	40°	V. slight,	V. slight,	.27	.0030	.0120	.22	.0200	.0001	.37	1.19	1.26	156

The following table contains the analyses of the canal water applied to Filters 8 and 18 A. It is brought through a small pipe, about four hundred feet long, from the canal of the Essex Company, and is substantially the same as the Merrimack River water above Lawrence, and as the water pumped into the city reservoir. It differs from the city water as drawn at the experiment station in containing more suspended matter and a much larger number of bacteria.

Weekly Analyses of Canal Water as drawn at the Lawrence Experiment Station.

Date.	Temperature.	Turbidity.	Sediment.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Aug. 19,	75°	Slight.	Slight.	.35	.0062	.0146	.24	.0130	.0001	.23	1,090
26,	77°	Slight.	Slight.	.25	.0074	.0138	.20	.0090	.0002	.19	1,360
Sept. 2,	70°	Slight.	Very slight.	.22	.0078	.0140	.17	.0110	.0002	.26	2,620
9,	68°	Slight.	Slight.	.25	.0080	.0120	.19	.0100	.0004	.28	5,000
16,	68°	Very slight.	Slight.	.21	.0048	.0154	.18	.0100	.0003	.25	2,394
23,	72°	Very slight.	Slight.	.22	.0064	.0146	.26	.0090	.0009	.22	1,350
30,	72°	Very slight.	Very slight.	.25	.0118	.0160	.26	.0130	.0018	.23	1,360
Oct. 7,	66°	Very slight.	Slight.	.20	.0072	.0150	.31	.0100	.0022	.24	11,400
14,	54°	Very slight.	Very slight.	.22	.0070	.0158	.31	.0120	.0006	.20	14,600
21,	55°	None.	Very slight.	.18	.0068	.0146	.30	.0160	.0006	.21	4,400
28,	48°	Very slight.	Very slight.	.22	.0056	.0142	.30	.0110	.0008	.28	3,500
Nov. 4,	45°	Very slight.	Slight.	.20	.0120	.0172	.32	.0150	.0016	.27	1,960
11,	46°	Very slight.	Very slight.	.20	.0154	.0158	.31	.0200	.0010	.26	3,520
18,	45°	Very slight.	Very slight.	.18	.0068	.0160	.30	.0140	.0006	.27	1,500
25,	44°	Very slight.	Very slight.	.23	.0080	.0174	.24	.0170	.0003	.31	6,200
Dec. 2,	38°	Very slight.	Very slight.	.40	.0070	.0176	.21	.0210	.0002	.64	3,500
9,	42°	Very slight.	Slight.	.23	.0044	.0162	.20	.0130	.0004	.41	3,500
16,	42°	Very slight.	Very slight.	.28	.0060	.0206	.19	.0210	.0002	.46	1,100
23,	40°	Very slight.	Very slight.	.26	.0078	.0154	.26	.0180	.0004	.40	4,200
30,	41°	Very slight.	Slight.	.31	.0034	.0124	.19	.0110	.0002	.45	1,200

The full results of the weekly analyses of the effluent of Filter Tank No. 8 are given in the following table. The numbers for bacteria given are the regular weekly counts; a more extended account of the numbers and of the various species found will be given subsequently in the report of the biological work of the station.

FILTER TANK NO. 8.

WEEK ENDING—	Quantity of Effluent. — Gallons per Acre Daily.	TEMPERATURE. Applied Water.	Effluent.	Water remained on Surface.	Av'rage depth of Frost Inches.	Date of Sample.	Color.	AMMONIA. Free.	Albuminoid.	Chlorine.	NITROGEN AS Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1889.														
Nov. 9,	243,543	51°	50°	24h.	-	Nov. 4,	0	.0008	.0072	.21	.0140	.0000	-	164
16,	213,200	50°	51°	24h.	-	11,	0	.0002	.0058	.21	.0110	.0000	-	15
23,	239,000	48°	48°	24h.	-	18,	0	.0002	.0058	.22	.0190	.0000	-	21
30,	249,800	47°	45°	-	-	25,	0	.0002	.0050	.22	.0140	.0000	-	4
Dec. 7,	238,628	44°	43°	-	-	Dec. 2,	0	.0002	.0050	.21	.0180	.0000	-	3
14,	221,057	43°	43°	-	-	9,	0	.0012	.0100	.18	.0180	.0000	-	4
21,	244,828	42°	39°	-	-	16,	0	.0000	.0044	.19	.0190	.0000	-	9
28,	206,143	42°	41°	-	-	23,	0	.0004	.0040	.19	.0200	.0000	-	11
1890.														
Jan. 4,	224,543	41°	41°	-	-	30,	0	.0006	.0054	.18	.0190	.0000	-	2
11,	181,286	40°	40°	-	-	Jan. 6,	0	.0002	.0048	.18	.0200	.0000	-	121
18,	168,914	39°	37°	-	-	13,	.1	.0004	.0062	.19	.0300	.0000	-	6
25,	151,571	38°	38°	-	-	20,	.1	.0006	.0078	.19	.0220	.0000	-	14
Feb. 1,	185,743	38°	36°	-	-	27,	.1	.0004	.0048	.19	.0200	.0000	-	13
8,	184,343	37°	37°	24h.	-	Feb. 4,	.1	.0012	.0040	.19	.0200	.0000	-	6
15,	241,629	37°	37°	24h.	2	11,	.1	.0012	.0068	.19	.0240	.0000	-	59
22,	202,714	37°	37°	-	-	18,	.1	.0006	.0050	.18	.0180	.0000	-	5
March 1,	224,629	37°	36°	-	-	25,	.1	.0008	.0060	.18	.0200	.0000	-	23
8,	184,171	36°	38°	-	-	March 4,	.1	.0006	.0068	.19	.0200	.0000	.11	9
15,	207,886	36°	36°	-	-	11,	0	.0008	.0078	.17	.0220	.0000	.09	5
22,	201,400	36°	39°	-	-	18,	0	.0008	.0064	.18	.0220	.0000	.09	4
29,	203,343	37°	40°	24h.	-	25,	0	.0010	.0074	.15	.0200	.0000	.13	2
April 5,	151,800	39°	40°	19h.40m.	-	April 1,	0	.0006	.0052	.15	.0230	.0000	.10	5
12,	155,229	40°	42°	24h.	-	8,	0	.0008	.0068	.15	.0360	.0000	.09	16
19,	145,486	42°	46°	17h.	-	15,	0	.0008	.0066	.16	.0280	.0000	.08	6
26,	150,457	44°	47°	20h.45m.	-	22,	0	.0014	.0082	.15	.0300	.0000	.10	10
May 3,	154,686	48°	48°	20h.	-	29,	0	.0014	.0068	.14	.0260	.0000	.08	9
10,	175,771	48°	54°	22h.30m.	-	May 6,	0	.0006	.0068	.14	.0360	.0000	.11	2
17,	183,086	51°	56°	19h.15m.	-	13,	0	.0018	.0058	.13	.0360	.0000	.10	8
24,	206,286	53°	59°	20h.35m.	-	20,	0	.0008	.0046	.12	.0320	.0000	.09	11
31,	215,428	54°	59°	20h.15m.	-	27,	0	.0008	.0064	.13	.0300	.0000	.09	10

City water applied 18 times a week till January 11, 12 times a week January 13 to March 24, and afterwards 6 times a week.

March 18, straw, leaves and other material removed and surface levelled.

Effluent clear and odorless.

FILTER TANK NO. 8 — *Continued.*

Week Ending —	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Applied Water.	Temperature. Effluent.	Water remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.														
June 7,	228,829	56°	61°	21h.11m.	-	June 3,	0	.0006	.0072	.13	.0200	.0000	.08	3
14,	227,457	57°	60°	20h.52m.	-	10,	.1	.0014	.0074	.13	.0280	.0000	.09	3
21,	229,314	58°	64°	20h.58m.	-	17,	0	.0016	.0068	.12	.0200	.0000	.11	0
28,	239,171	62°	69°	21h.12m.	-	24,	0	.0006	.0048	.15	.0280	.0000	.07	7
July 5,	251,057	64°	70°	20h.13m.	-	July 1,	0	.0004	.0042	.16	.0240	.0000	.07	7
12,	254,686	66°	72°	21h.	-	8,	0	.0002	.0056	.18	.0300	.0000	.06	5
19,	240,086	69°	73°	20h.30m.	-	15,	0	.0010	.0046	.20	.0260	.0000	.07	3
26,	255,314	69°	70°	-	-	22,	0	.0006	.0042	.23	.0220	.0000	.08	4
Aug. 2,	249,171	69°	73°	-	-	29,	0	.0004	.0034	.23	.0280	.0000	.03	6
9,	244,743	71°	75°	-	-	Aug. 5,	0	.0012	.0078	.22	.0240	.0000	.06	-
16,	238,000	71°	72°	18h.	-	12,	0	.0014	.0050	.22	.0240	.0000	.05	-
23,	248,914	70°	73°	18h.	-	19,	0	.0010	.0054	.23	.0230	.0000	.05	-
30,	248,486	69°	70°	18h.30m.	-	26,	0	.0004	.0050	.22	.0220	.0000	.07	-
Sept. 6,	237,143	67°	70°	20h.35m.	-	Sept. 2,	0	.0006	.0052	.21	.0200	.0000	.04	0
13,	253,257	67°	69°	19h.50m.	-	9,	0	.0006	.0050	.19	.0230	.0000	.06	-
20,	248,200	66°	69°	-	-	16,	0	.0002	.0048	.16	.0220	.0000	.09	-
27,	233,029	65°	66°	-	-	23,	0	.0006	.0056	.16	.0260	.0000	.10	5
Oct. 4,	224,086	62°	63°	22h.45m.	-	30,	0	.0004	.0046	.20	.0180	.0000	-	3
11,	221,200	61°	61°	23h.	-	Oct. 7,	0	.0002	.0038	.16	.0220	.0000	.09	5
18,	217,686	58°	58°	23h.45m.	-	14,	0	.0006	.0040	.18	.0160	.0000	.12	12
25,	105,518	55°	55°	23h.	-	-	-	-	-	-	-	-	-	-
Nov. 1,	187,314	53°	50°	24h.	-	28,	-	.0000	.0030	.21	.0180	.0000	.12	4
8,	189,257	51°	48°	24h.	-	Nov. 4,	.07	.0004	.0040	.19	.0230	.0000	.06	1
15,	161,886	49°	47°	24h.	-	11,	.04	.0004	.0044	.16	.0160	.0000	.13	2
22,	131,943	48°	46°	24h.	-	18,	.04	.0008	.0056	.19	.0190	.0000	.11	4
29,	176,371	47°	43°	24h.	1¼	25,	.06	.0004	.0052	.16	.0320	.0000	.14	5
Dec. 6,	135,457	44°	42°	-	½	Dec. 2,	.07	.0000	.0058	.20	.0320	.0000	.12	4
13,	131,543	42°	43°	-	1	9,	.05	.0006	.0036	.22	.0460	.0000	.10	5
20,	159,286	40°	37°	-	¼	16,	.05	.0002	.0066	.21	.0430	.0000	.11	8
27,	143,257	38°	36°	-	-	23,	.04	.0006	.0052	.22	.0320	.0000	.12	12

City water applied 6 times a week.
Snow and ice removed from surface December 11, 18, 26, 27 and 30.
Experiments interrupted by high water in the river October 21 and 22.
Effluent clear and odorless.

FILTER TANK No. 8 — *Continued.*

Week Ending —	Quantity of Effluent. — Gallons per Acre Daily.	Temperature.		Water remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.					Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.														
Jan. 3,	161,286	38°	36°	-	1	Dec. 31,	.04	.0004	.0054	.27	.0280	.0000	.10	11
10,	154,257	38°	35°	-	¼	Jan. 7,	.06	.0008	.0052	.26	.0260	.0000	.16	12
17,	196,629	38°	35°	-	0	14,	.04	.0006	.0050	.24	.0240	.0000	.12	5
24,	166,771	38°	36°	-	¼	21,	.05	.0002	.0042	.18	.0240	.0000	.11	44
31,	148,514	38°	36°	24h.	¼	28,	.05	.0010	.0054	.18	.0260	.0001	.12	2
Feb. 7,	177,800	37°	37°	24h.	0	Feb. 4,	.05	.0004	.0044	.16	.0340	.0000	.11	0
14,	163,743	37°	36°	24h.	0	11,	.05	.0004	.0040	.17	.0250	.0000	.10	13
21,	172,629	36°	38°	24h.	0	18,	.05	.0004	.0044	.19	.0250	.0000	.12	0
28,	159,343	37°	37°	24h.	¾	25,	.05	.0000	.0030	.17	.0220	.0000	.11	5
March 7,	191,229	37°	37°	24h.	½	March 4,	.05	.0006	.0056	.19	.0180	.0000	.10	3
14,	150,650	37°	39°	-	0	11,	.05	.0006	.0036	.14	.0290	.0000	.09	7
21,	0	-	-	-	1½	-	-	-	-	-	-	-	-	-
28,	0	-	-	-	0	-	-	-	-	-	-	-	-	-
April 4,	244,333	38°	43°	21h.40m.	0	April 1,	.06	.0038	.0020	.15	.0340	.0000	.13	3
11,	222,514	39°	42°	22h.40m.	0	8,	.05	.0042	.0032	.16	.0360	.0000	.08	10
18,	32,030	-	-	16h.	-	-	-	-	-	-	-	-	-	-
25,	149,600	45°	52°	21h.37m.	-	22,	.05	-	.0040	.15	.0490	.0000	.05	12
May 2,	241,143	48°	52°	-	-	29,	.07	.0000	.0038	.15	.0410	.0000	.13	4
9,	236,057	50°	52°	23h.37m.	-	May 6,	.07	.0022	.0038	.14	.0290	.0000	.11	11
16,	229,286	52°	56°	23h.15m.	-	13,	.06	.0006	.0032	.15	.0330	.0000	.08	1
23,	236,629	53°	57°	22h.	-	20,	.04	.0004	.0034	.14	.0250	.0000	.10	8
30,	230,486	55°	61°	24h.	-	27,	.05	.0006	.0038	.20	.0320	.0000	.12	2
June 6,	228,771	57°	62°	22h.37m.	-	June 3,	.05	.0000	.0030	.16	.0350	.0000	.10	14
13,	219,914	59°	64°	-	-	10,	.05	.0000	.0036	.20	.0290	.0000	.10	3
20,	220,857	62°	69°	24h.	-	17,	.05	.0000	.0040	.16	.0380	.0000	.09	6
27,	223,800	63°	67°	24h.	-	24,	.04	.0006	.0034	.15	.0310	.0000	.08	1
July 4,	219,171	64°	68°	-	-	July 1,	.04	.0006	.0038	.20	.0330	.0000	.07	22
11,	223,771	65°	68°	21h.30m.	-	8,	.04	.0002	.0054	.19	.0330	.0000	.11	-
18,	211,571	68°	72°	-	-	15,	.04	.0000	.0032	.22	.0400	.0000	.12	-
25,	204,657	70°	72°	-	-	22,	.04	.0010	.0034	.23	.0330	.0000	.09	7

City water applied 6 times a week.

Surface raked about 1 inch deep each week, commencing Jan. 1, 1891.

Snow and ice removed from surface January 6, 12, 20, 26, February 9, 16, March 2, 4 and 5.

Experiments interrupted by high water in the river January 25, 26, February 27, 28, March 1, 12 to 29, April 14 to 18.

Effluent clear and odorless.

FILTER TANK NO. 8 — *Concluded.*

Week Ending —	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Applied Water.	Temperature. Effluent.	Water remained on Surface.	Av'age Depth of Frost. Inches.	Date of Sample.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.														
Aug. 1,	199,028	69°	70°	-	-	July 29,	.04	.0002	.0048	.23	.0280	.0000	.08	1
8,	218,256	68°	70°	-	-	Aug. 5,	.03	.0002	.0028	.22	.0300	.0000	.04	0
15,	200,543	70°	74°	-	-	12,	.03	.0000	.0044	.22	.0370	.0000	.02	2
22,	229,343	71°	73°	-	-	19,	.03	.0000	.0034	.24	.0310	.0000	.01	0
29,	218,143	71°	74°	-	-	26,	.04	.0002	.0034	.21	.0290	.0000	.03	6
Sept. 5,	212,714	70°	69°	21h.10m.	-	Sept. 2,	.02	.0002	.0038	.24	.0260	.0000	.05	2
12,	219,171	67°	68°	22h.30m.	-	9,	.02	.0012	.0028	.19	.0320	.0000	.06	1
19,	212,029	67°	68°	24h.	-	16,	.03	.0002	.0038	.18	.0310	.0000	.05	1
26,	195,914	67°	70°	23h.6m.	-	23,	.04	.0000	.0038	.23	.0320	.0000	.01	1
Oct. 3,	201,743	68°	70°	24h.	-	30,	.02	.0008	.0050	.25	.0320	.0000	.04	-
10,	212,600	66°	65°	23h.19m.	-	Oct. 7,	.02	.0004	.0056	.29	.0320	.0000	.03	1
17,	219,771	61°	58°	24h.	-	14,	.02	.0002	.0032	.30	.0270	.0000	.03	1
24,	187,286	56°	55°	24h.	-	21,	.02	.0004	.0042	.30	.0340	.0000	.04	5
31,	204,371	52°	50°	-	-	28,	.02	.0002	.0042	.30	.0310	.0000	.02	0
Nov. 7,	191,257	49°	48°	24h.	-	Nov. 4,	.03	.0004	.0036	.30	.0300	.0000	.09	0
14,	163,171	46°	47°	24h.	-	11,	.03	.0000	.0034	.30	.0340	.0000	.03	0
21,	173,857	44°	46°	24h.	-	18,	.03	.0002	.0022	.30	.0300	.0000	.02	0
28,	125,657	43°	45°	24h.	-	25,	.03	.0006	.0044	.25	.0380	.0000	.01	0
Dec. 5,	140,400	39°	44°	24h.	¼	Dec. 2,	.03	.0002	.0038	.23	.0240	.0000	.09	0
12,	122,714	42°	43°	24h.	-	9,	.04	.0002	.0046	.26	.0280	.0000	.06	0
19,	124,971	39°	42°	23h.20m.	0	16,	.05	.0004	.0044	.22	.0240	.0000	.08	0
26,	114,514	41°	42°	24h.	0	23,	.02	.0002	.0032	.26	.0300	.0000	.08	1
-	-	-	-	-	-	30,	.03	.0002	.0024	.26	.0300	.0000	.07	0

City water applied 6 times a week to November 12 and afterwards canal water applied 6 times a week. Surface raked about 1 inch deep each week.

Effluent clear and odorless.

The following table contains a summary of twenty-five microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 8.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Melosira,	4	1	25
Algæ. Chlorococcus,	4	1	25
Fungi. Molds,	4	1	25
ANIMALS.			
Infusoria. Monas,	8	4	75
Vermes. Anguillula,	4	1	25

The following table contains the averages, by months, of the weekly analyses of the effluent of Filter Tank No. 18 A: —

FILTER TANK NO. 18 A.

Date.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Applied Water.	Temperature. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
December,	420,000	41°	42°	.15	.0004	.0071	.21	.0368	.0000	.19	93
1891.											
January,	840,000	38°	42°	.13	.0008	.0068	.19	.0222	.0000	.20	17
February,	940,000	37°	47°	.14	.0004	.0060	.16	.0212	.0001	.22	12
March,	960,000	37°	48°	.13	.0008	.0059	.15	.0203	.0000	.18	29
April,	980,000	42°	49°	.14	.0002	.0052	.15	.0230	.0000	.15	25
May,	1,160,000	52°	58°	.12	.0004	.0040	.14	.0230	.0000	.15	17
June,	1,120,000	60°	68°	.13	.0002	.0064	.16	.0235	.0000	.17	5
July,	1,100,000	67°	72°	.11	.0004	.0063	.21	.0246	.0000	.17	11
August,	980,000	70°	73°	.10	.0006	.0059	.22	.0205	.0000	.10	4
September,	1,740,000	68°	69°	.12	.0006	.0081	.21	.0282	.0000	.15	72
October,	1,500,000	59°	57°	.11	.0006	.0088	.31	.0305	.0001	.14	149
November,	860,000	49°	45°	.14	.0009	.0077	.29	.0325	.0000	.15	103
December,	900,000	42°	44°	.21	.0008	.0076	.22	.0248	.0000	.28	2

City water applied until Aug. 18, 1891; afterwards canal water.

Experiments interrupted by high water in the river February 27 to March 1, March 12 to 16 and April 12 to 17; also March 20 to April 9, for repairs.

A summary of twenty-five microscopical examinations of the effluent is given in the following table:—

Microscopical Examination of Effluent of Filter Tank No. 18 A.

[Number of organisms per 100 cubic centimeters.]

ORGANISMS.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Synedra,	4	1	25
Algæ.			
Chlorococcus,	16	32	725
Protococcus,	4	1	25
Ulothrix,	4	5	125
Fungi. Molds,	4	1	25
ANIMALS.			
Infusoria. Monas,	8	26	600
Vermes. Rotatorian ova,	8	22	500

The averages, by months, of the weekly analyses of Filter Tank No. 20 A are given in the following table:—

FILTER TANK NO. 20 A.

DATE.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Applied Water.	Temperature. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890.											
August,	460,000	68°	74°	.10	.0010	.0062	.22	.0252	.0000	.15	32
September,	520,000	65°	70°	.12	.0012	.0075	.18	.0248	.0000	.16	8
October,	200,000	55°	-	.03	.0004	.0059	.19	.0316	.0000	.19	21
November,	520,000	50°	-	.16	.0008	.0079	.17	.0220	.0000	.24	9
December,	380,000	41°	-	.14	.0003	.0066	.20	.0370	.0000	.21	9
1891.											
January,	140,000	38°	43°	.12	.0008	.0059	.19	.0262	.0000	.17	8
February,	120,000	37°	45°	.11	.0004	.0053	.16	.0237	.0000	.17	33
March,	60,000	37°	42°	.11	.0005	.0053	.15	.0260	.0000	.13	94
April,	100,000	42°	51°	.13	.0010	.0053	.15	.0313	.0000	.13	4
May,	280,000	52°	57°	.12	.0005	.0057	.14	.0242	.0000	.16	7
June,	300,000	60°	69°	.11	.0002	.0055	.16	.0257	.0000	.15	13
July,	340,000	67°	71°	.10	.0004	.0056	.21	.0278	.0000	.15	5
August,	340,000	70°	74°	.08	.0005	.0052	.22	.0297	.0000	.10	3
September,	460,000	68°	66°	.07	.0012	.0054	.21	.0306	.0000	.11	6
October,	420,000	59°	51°	.06	.0006	.0063	.29	.0307	.0000	.11	12
November,	480,000	49°	46°	.08	.0003	.0051	.28	.0342	.0000	.11	1
December,	380,000	42°	45°	.12	.0009	.0062	.25	.0336	.0000	.15	0

Experiments interrupted by high water in the river February 27 to March 1, March 12 to 16 and April 12 to 17.

The following table contains a summary of twenty-seven microscopical examinations of the effluent: —

Microscopical Examination of Effluent of Filter Tank No. 20 A.

[Number of organisms per 100 cubic centimeters.]

Organisms.	Percentage of Times Found to Total Number of Observations.	Average Number.	Maximum Number.
PLANTS.			
Diatomaceæ. Melosira,	4	3	75
Algæ.			
Chlorococcus,	12	14	175
Closterium,	4	2	50
Ulothrix,	4	3	75
Fungi.			
Beggiatoa,	4	2	50
Molds,	4	1	25
ANIMALS.			
Vermes. Rotatorian ova,	4	1	25

SPECIAL BIOLOGICAL WORK.

The following account of the special biological work of the station has been prepared by Mr. George W. Fuller, biologist in charge.

The regular biological work has consisted in part, as in former years, in the systematic examination, both microscopical and bacterial, of the applied sewage, city water and canal water, and of the effluents of the different filters. The microscopical examinations have been made after the Sedgwick-Rafter method (see p. 397). In the bacterial analyses unusual care has been taken to make the determinations under conditions as nearly as possible parallel, in order that the results might be directly comparable. Since it has been observed, both in this laboratory and elsewhere, that nutrient gelatine, varying even to a moderate extent in its degree of alkalinity, may yield widely differing numbers of bacteria from duplicate samples of water, — a circumstance probably due to the fact that different species of bacteria require different degrees of alkalinity for their rapid development, — numerous experiments have been made to determine the optimum amount of alkali necessary for the development of those species of bacteria prevailing in the waters and sewage of Lawrence. A special study has also been made of the methods available for securing the same degree of alkalinity in all samples of nutrient gelatine, but it has been found difficult to obtain an indicator sufficiently sensitive to all the compounds present in the gelatine; and it has occasionally been observed that lots of nutrient gelatine, which had been made alkaline to the same degree, so far as could be determined by the ordinary indicators, have also given widely varying numbers of bacteria in duplicate samples of the same water.

As a step toward greater precision in manipulation, all gelatine plates have been grown not at the "room temperature," as is usual, but in a low-temperature thermostat. This thermostat, which eliminates irregular temperature differentiations, is kept at 20° C. during the summer months by passing a stream of cold water through the

water jacket, and, during the rest of the year, by a small gas flame. Devices have also been introduced for protecting the effluents from contamination by dust and air; a careful study has been made of the conditions and methods of taking samples; and these things, together with the use of a nutrient gelatine of a composition as nearly as possible uniform, and under parallel conditions, have served to increase the accuracy of the biological methods of determining the degree of purification of sewage and water. The results of the regular biological analyses have already been tabulated and discussed along with the chemical results on the foregoing pages. (See tables above, showing the chemical and biological purification effected by the different filters.)

Investigations upon the Bacillus of Typhoid Fever.

The importance of determining accurately the life-history of the typhoid fever bacillus, its deportment in sewage and in water, and the possibility of its removal from water by means of filtration, has long been recognized as an important part of the biological work. When the problem was first undertaken, it was found that there was no reliable method for its differentiation from several species of bacteria regularly present in the water of the Merrimack River at Lawrence. The potato test, upon which much dependence was generally placed, has proved to be totally inadequate, and for two reasons: first, because the typhoid fever bacillus does not under all conditions give its characteristic invisible growth on sterilized potato; and, second, because no fewer than five of the species in the Lawrence waters under some circumstances present the same characteristic.

After it had been discovered that the potato test was not diagnostic, and that it was even contradictory, it became necessary to devise other methods of differentiation. To this end a thorough study was made of the typhoid bacillus, side by side with the species of bacteria present in the water of the Merrimack River at Lawrence. The numerous special methods and media proposed for its differentiation were examined and their diagnostic value determined. This preparatory investigation was continued for several months, and resulted in a method of procedure whereby the typhoid fever bacillus can be differentiated beyond all reasonable doubt from every species of bacteria hitherto met with in the Lawrence waters. The results of this investigation are embodied in a paper which appears beyond (p. 635).

Up to this point all study and comparisons of the typhoid bacillus were made with cultures which had been obtained from prominent laboratories in New York, Paris and Berlin. These cultures had not been freshly isolated; in fact, it was believed that with one possible exception they were several years old and probably of diminished vitality, as was indicated by their inability to grow at the extreme limits of temperature which have been determined for this organism. As it was very desirable to continue these investigations with a culture of undoubted identity and of undiminished vitality, a fresh culture was necessary. Accordingly, after some difficulty and by means of the methods which have just been referred to, there was isolated from the fæces of a patient having a typical case of typhoid fever at the Lawrence General Hospital, a bacillus which, after long and careful study, appeared to be in every way identical on all culture media with typhoid cultures obtained from Prudden of New York and from Chantemesse of Paris. It also agreed very closely with the most reliable descriptions. It is of interest to note that the fæces were passed on the fifth day of the patient's illness. In the course of these investigations, eleven complete examinations of typhoid fæces and three of typhoid urine were made, in which the specific organism could not be found. It may be observed in passing that the rejection of the potato test for typhoid fever bacilli has made necessary a re-examination of many of the accepted data in this disease. A thorough study of typhoid fæces is especially required.

In addition to these necessary investigations, which covered a period of more than six months, experiments were made which indicated that typhoid fever germs are able to survive in the water of the Merrimack River, but in greatly diminished numbers, for a period of at least three weeks, — sufficiently long to enable these germs to pass from the Lowell sewers to the service pipes of the Lawrence water supply. The conditions were also studied for the application of these germs, in large numbers, to the several water filters. The composition of the nutrient media, in which the germs could be best grown and applied to the filters, was investigated, both with respect to the typhoid fever bacillus itself and to the ordinary species present in the river water. These and other details were worked out and have since been applied in the numerous experiments upon water filtration which are in progress during the present year, some of which are summarized in the preceding section.

DETERMINATIONS OF SPECIES OF BACTERIA.

In the course of the investigations upon typhoid fever bacilli much was learned concerning the species of ordinary water bacteria. It became necessary to compare the species of bacteria found in the effluents with those in the water or sewage applied to the several filters. Filter Tank No. 8, filtering at first city water and afterwards river water, was selected for exhaustive study, and the results are given in detail below. It soon became evident that the degree of bacterial purification in this case must be learned, not so much by study of the morphological and physiological characteristics of a few species of bacteria in the applied water and in the effluent, as by a long-continued and systematic comparison of all of the species, and the number of each present in the water before and after its passage through the filter. To this end, it became necessary to devise means by which the species could be readily recognized, and also for estimating the number of each species of bacteria present in the sample of water.

A method was devised which consisted in examining all of the colonies on the gelatine plate, and estimating the number of each kind presenting marked characteristics. This placed together in groups, kinds superficially resembling one another. One or more colonies of each group were "fished," and ten or more colonies possessing no marked characteristics on the gelatine plate (including many non-liquefying colonies lying beneath the surface) were taken at random; and, in case of less than ten such colonies, all were taken. Fortunately plates were seldom seen in this work which contained more than twenty-five colonies. To facilitate the separations, dilutions of one to one hundred were made of the river water. After the species of bacteria were recognized the number present of those possessing marked characteristics on the gelatine plate was easily calculated, and of the remainder each species was given its aliquot portion. During the earlier part of the work the following tests were used in the species determinations: —

1. Examination in the hanging drop, of bouillon culture two days old.
2. Examination of stained preparations from a seven-days-old agar culture, with particular reference to spore formation.
3. Growth on the gelatine plate.
4. Growth in the gelatine tube.
5. Growth on the agar plate incubated at 37° C.

6. Growth on the inclined agar tube (both at 20° C. and at 37° C).
7. Growth in bouillon.
8. Growth on potato.
9. Reduction of nitrates in peptone solution.
10. Formation of turbidity or of gas, or of both, in closed arm in the Smith test.*
11. Coagulation of milk (observations made both before and after boiling).
12. Fermentation of milk (quantitative determination of acid or alkali).

With a thorough knowledge of the species in a particular case, the amount of labor in identifying them may be much reduced. Thus it was learned that in many cases the growth on potato, under the mica plate on gelatine, in bouillon, and the examination in the hanging drop, gave no differentiations which were not as well shown by the other tests. They were accordingly omitted in some cases, although they were made from time to time, to ascertain that no new species of bacteria had become prominent without detection. The conditions of determination were made as nearly as possible parallel, both with regard to time and temperature. On account of the large number of determinations necessary, it was not possible in this particular inquiry to follow each culture carefully, day by day. In fact, at the outset it was apparent that this method of procedure might result in giving groups of closely related species, rather than the rigid separation of individual species. But in this investigation it was far more important to obtain an accurate quantitative determination of all the groups of species in both applied water and effluent than a more detailed study of a limited number. A careful study and classification of the data obtained has readily indicated the appearance from time to time of new species, and as a matter of fact this method of species determination, after several months' trial, has proved to be trustworthy.

A close examination of the species included in the several groups has revealed the important fact that the microscopic flora of the Merrimack River includes not an infinite number of kinds of bacteria but only about thirty prevailing species.

Total Removal of Bacteria from the Applied Water by Filter Tank No. 8.

This filter, which is described on pp. 607–617, has filtered city water intermittently, at the average rate of 183,000 gallons per acre daily, during 1891. Beginning in May, 1891, the attempt was made

* Centralblatt für Bakteriologie, Bd. VII., p. 502.

to determine with certainty whether any of the bacteria found in the effluent came down through the filtering material with the applied water. The sanitary importance of determining this point is obvious, since one of the principal objects of water filtration is the removal of pathogenic bacteria. Elaborate preparations were therefore made to settle this difficult question. The degree of bacterial purification accomplished by Filter Tank No. 8, indicated by the number of bacteria in the water before and after passing through it, is shown by the following table: —

Table of Monthly Averages of the Number of Bacteria found in a Cubic Centimeter of City Water and in the corresponding Effluent from Filter Tank No. 8.

Month. 1891.	City Water.		Effluent from Filter No. 8.		Percentage of Bacteria Removed by Filter.
	Bacteria.	Number of Determinations.	Bacteria.	Number of Determinations.	
May,	68	6	3.2	37	95.3
June,	112	4	3.3	42	97.1
July,	189	4	12.6	15	93.3
August,	181	4	2.0	4	98.9
September,	144	5	2.0	19	98.6
October,	357	4	5.4	42	98.5
Totals,	175	27	4.7	159	97.3

In January, 1890 (see Special Report on Purification of Sewage and Water, 1890, page 615), it was shown that there was a growth of bacteria in the underdrains and outlet pipe of this filter. This was proved by examination of the water expressed from a sterilized sponge after wiping out the pipe. This operation was repeated several times in 1891. The species present in the air and dust were obtained by exposing a sterile gelatine plate in the vicinity of the outlet pipe. These species of bacteria, as well as those found in the outlet pipe and underdrains, were quantitatively determined.

In the following table a comparison is shown of the results of the quantitative determination of the species of bacteria in the applied city water, in the effluent, the air, the outlet pipe and the underdrains. In the case of air the figures indicate the percentage which each species forms of the total number of bacteria on the plates. It is to be noted that it was during this period that the quantitative method of species determinations was developed, and;

although the work was done as carefully as possible, the results are somewhat less accurate than those obtained after more experience with the method.

Average Results of Quantitative Determinations of the Species of Bacteria. May to August, inclusive, 1891.

From —	Number of Determinations.	Species of Bacteria. (Average Number per Cubic Centimeter.) No. 26.0.	No. 26.1.	No. 24.	No. 5.	No. 35.	No. 20.	No. 20.1.	No. 11.0.	No. 11.2.	No. 39.	No. 55.	No. 54.	Totals.
City water, . . .	9	0.4	2.	0.7	5	8.	34	2	57		1	5	0	115
Effluent from Filter Tank No. 8, . .	47	0.5	1.	0.15	0.6	0.15	0.9	0.1	1.1		0.2	0.25	0.5	5.25
Outlet pipe and underdrains, . . .	5	1.	1.	0	1.0	0.5	2.14	1.02	0		0	0.5	0	320
Air,*	13	3	2	16	0	0	2	22	35		7	11	2	100

* Percentage of total number found.

September and October, 1891.

From —	Number of Determinations.	No. 26.0.	No. 26.1.	No. 24.	No. 5.	No. 35.	No. 20.	No. 20.1.	No. 11.0.	No. 11.2.	No. 39.	No. 55.	No. 54.	Totals.
City water, . . .	6	3	0	10	36	46	83	0	12	22	0	15	0	227
Effluent from Filter Tank No. 8, . .	37	0.16	0	0.24	0.19	0.81	0.42	0	0.14	0	0	0	0	1.96
Outlet pipe and underdrains, . . .	5	6	0	1.4	3.2	7.4	2.6	0	1.6	0	0	0	0	22.2

It will be seen that the species are designated by numbers, and not by names. For reasons stated above, this work has been one of comparative and quantitative species determination, rather than a detailed study of the species themselves. As nearly as can be learned, however, from the comparisons made up to this time, the numbers used in these tables signify, and doubtless in most cases are identical with, previously described species, as indicated below: —

No. 26 = *B. cereus*, Frankland.
No. 24 = *B. subtilis*, Cohn.
No. 5 = *B. cloacæ*, Jordan.
No. 35 = *B. fluorescens liquefaciens*, Flügge.
No. 20 = *B. candicans*, Frankland.
No. 11.2 = *B. coli communis*, Escherich.
No. 57 = *B. ubiquitus*, Jordan.
No. 55 = *B. aurantiacus*, Frankland.
No. 150 = red yeast.

In studying the first portion of the table given above, it will be seen that species Nos. 20 and 11.0, which form more than eighty per cent.

of the bacteria in the applied water, constitute less than forty per cent. of those in the effluent. These two species are very prominent ones in the underdrains (No. 20) and in the air (No. 11.0). A comparison of the remaining species indicates, also, that it is far more reasonable to conclude that they have had their origin in either the underdrains or the air, than that they have passed with the applied water (containing very small numbers) through the filtering material. The second portion of the table shows a very striking resemblance between not only the species of bacteria but their relative numbers, in the effluent and those in the underdrains and outlet pipe. The relation of the species and their numbers, in the case of the bacteria of the applied water and the effluent, is far less marked; while two species present in the applied water, No. 11.2 = *B. coli communis*, and No. 55 = *B. aurantiacus*, were not found in the effluent.

The investigation up to this point confirmed the results of the work of previous years; namely, that the few bacteria in the effluent have their origin in the underdrains and outlet pipe, and do not pass through the filter. In order to obtain still more definite data, it was determined to increase as much as possible the number of applied bacteria, and to guard, with the utmost care, against contamination of the effluent. To this end "canal" water taken from the Merrimack River above Lawrence, and containing from one thousand to fifteen thousand bacteria in a cubic centimeter, was applied to the filter, commencing Nov. 13, 1891. The effluent was protected from contamination by dust and air by covering the outlet pipe with a large zinc-lined box, which was frequently washed with corrosive sublimate, and so arranged that the stopper of a sample bottle could be removed beneath it and all manipulations could be done without disturbing it.

From the date of application of canal water to the filter several determinations of the number of bacteria in the applied water and in the effluent were made daily from samples collected at different hours. The results are as follows: —

Summary of Bacterial Counts. (Nov. 13—Dec. 31, 1891.)

	Average Number of Bacteria in a Cubic Centimeter.	Number of Determinations.	Percentage of Bacteria removed by Filter.
Canal water, ...	2,660	88	-
Effluent from Filter Tank No. 8, ...	0.83	102	99.97

Of the one hundred and two determinations made of the effluent, fifty-eight showed no colonies on the gelatine plates. The determinations of the number of bacteria in canal water and in the effluent from Filter Tank No. 8 were made on the same gelatine, grown for the same length of time and at the same temperature. Many duplicate determinations were made of the effluent, and the plates were allowed to stand eight and even ten days before counting. They agreed very well with those counted after three days; rarely a colony was found which proved to be a spore-former, and had no relation to the leading species in the applied water.

A quantitative species determination was made of all samples of Filter Tank No. 8 effluent, as well as of canal water, at frequent intervals. The results are given below. It will be seen that these determinations indicated the presence of twelve species in the canal water. This does not mean that they were the only species of bacteria present, but that these species were the leading ones, occurring in numbers sufficiently great to be found on plates of samples diluted one to one hundred.

Number of Bacteria of Each Species found in a Cubic Centimeter of Canal Water.

Date.	Total Number of Bacteria.	Species of Bacteria.															
		No. 26.0.	No. 26.1.	No. 24.	No. 5.	No. 85.	No. 20.	No. 20.1.	No. 11.0.	No. 11.2.	No. 610.	No. 57.	No. 66.	No. 39.	No. 55.	No. 150.	No. 81.
1891.																	
Nov. 13,	2,100	-	-	-	300	200	600	-	-	700	300	-	-	-	-	-	-
14,	900	-	-	-	-	200	600	-	-	-	-	-	-	100	-	-	-
16,	1,500	-	-	-	150	200	-	300	-	150	-	400	-	-	300	-	-
17,	235	-	-	-	-	9	-	28	-	138	-	60	-	-	-	-	-
19,	1,500	-	-	-	-	-	-	300	-	350	500	350	-	-	-	-	-
19,	2,500	-	-	-	800	-	-	1,100	200	-	200	-	-	200	-	-	-
21,	15,000	-	-	-	-	1,000	-	2,000	1,000	11,000	-	-	-	-	-	-	-
23,	1,100	-	-	-	375	125	125	-	-	125	-	-	350	-	-	-	-
25,	6,700	-	-	-	1,300	-	2,300	-	-	1,300	-	600	600	-	-	-	600
30,	800	-	-	-	100	-	100	-	200	400	-	-	-	-	-	-	-
Dec. 2,	3,400	-	-	-	900	-	300	600	500	600	-	250	-	-	250	-	-
10,	2,000	-	-	-	-	250	-	500	500	-	-	250	-	-	-	-	500
16,	1,100	-	-	-	-	-	250	-	-	250	-	-	600	-	-	-	-
26,	552	-	-	-	115	60	-	87	60	170	-	-	-	-	60	-	-
Averages,	2,814	0	0	0	288	146	305	350	175	1,085	71	136	110	21	44	0	79

Number of Bacteria of Each Species Found in a Cubic Centimeter of Effluent from Filter Tank No. 8.

Date.	Total Number of Bacteria.	Species of Bacteria.																
		No. 26.0.	No. 26.1.	No. 24.	No. 5.	No. 35.	No. 20.	No. 20.1.	No. 11.0.	No. 11.2.	No. 610.	No. 57.	No. 66.	No. 39.	No. 55.	No. 150.	No. 81.	Undetermined.
1891.																		
Nov. 14,	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
14,	2	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15,	2	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
16,	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
16,	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
16,	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
17,	3	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-
17,	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
17,	2	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
18,	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
18,	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19,	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
19,	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
20,	2	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-
22,	2	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
23,	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
23,	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23,	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
24,	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
24,	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Dec. 3,	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
4,	8	-	-	-	-	-	-	-	2	-	-	1	4	-	-	-	-	1
4,	3	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1
4,	3	-	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-
5,	6	-	-	-	-	-	-	-	5	-	-	1	-	-	-	-	-	-
8,	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9,	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
10,	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
10,	2	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
12,	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
15,	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
16,	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
17,	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
18,	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-

Number of Bacteria of Each Species Found in a Cubic Centimeter of Effluent from Filter Tank No. 8 — Concluded.

DATE.	Total Number of Bacteria.	SPECIES OF BACTERIA.																
		No. 26.0.	No. 26.1.	No. 24.	No. 5.	No. 35.	No. 20.	No. 20.1.	No. 11.0.	No. 11.2.	No. 610.	No. 57.	No. 66.	No. 39.	No. 55.	No. 150.	No. 81.	Undetermined.
1891.																		
Dec. 18,	2	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-
19,	3	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-
19,	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21,	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
21,	4	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
24,	2	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-
26,	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
28,	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28,	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
28,	2	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Averages,*	0.83	0.06	0.01	0.13	0.15	0.05	0.02	0	0.12	0	0.02	0.07	0.09	0.02	0.01	0.03	0	0.05

* Including 58 determinations which indicated a sterile effluent.

Table showing the Average Number of Each Species of Bacteria in a Cubic Centimeter in Canal Water and in the Effluent from Filter Tank No. 8.

	SPECIES OF BACTERIA.															
	No. 26.0.	No. 26.1.	No. 24.	No. 5.	No. 35.	No. 20.	No. 20.1.	No. 11.0.	No. 11.2.	No. 610.	No. 57.	No. 66.	No. 39.	No. 55.	No. 150.	No. 81.
Canal water, .	0	0	0	258	146	315	350	175	1,085	71	136	110	21	44	0	79
Effluent, Filter Tank No. 8, .	0.06	0.01	0.13	0.15	0.05	0.02	0	0.12	0	0.02	0.07	0.09	0.02	0.01	0.03	0

The results of this investigation may be stated as follows: —

1. The application of water taken from the canal (Merrimack River water), instead of city water which contains a much smaller number of bacteria, commencing Nov. 13, 1891, was followed by a decrease rather than an increase in the total number of bacteria found in the effluent from Filter Tank No. 8. The decrease was due to improved manipulation.

2. No relation could be distinguished between the rates of flow and the number of bacteria in the effluent.

3. The quantitative determination of the species of bacteria in the applied canal water and in the effluent indicated that three prominent species, Nos. 20.1, 11.2 and 81, were not present in the water after its passage through the filter. Of these species, No. 11.2 is *B. coli communis*, the leading species in human fæces, and also, during November and December, 1891, in the water of the Merrimack River at Lawrence, in which it formed thirty-nine per cent. of the bacteria. It is also to be remembered that this species resembles very closely the bacillus of typhoid fever.

4. The presence of the very small numbers of bacteria in the effluent was satisfactorily explained by their specific similarity to those present in the air, the outlet pipe and the underdrains.

5. Of the one hundred and two bacterial examinations made of the effluent from November 14 to December 31, inclusive, fifty-eight proved to be sterile.

From this evidence it is fair to conclude that with the filtering materials here used all of the bacteria of the Merrimack River may be removed by intermittent filtration. This important result has not been reached hitherto.

Determination of the Species of Bacteria from Different Points in the Lawrence Water Supply.

Beginning on Jan. 1, 1891, a series of determinations was made, once a month or oftener, of the numbers of bacteria found in the water of the Merrimack River from samples taken, first, from the force main at the pumping station of the Lawrence water works, second, in the water after it has passed through the reservoir, and again at certain points along its passage through the service pipes. In connection with the results, which are given in the following table, it is to be stated that the reservoir, where the greatest bacterial purification takes place, has a capacity equal to about two weeks' consumption, and that the city hall is distant about one and one-half miles, and the Experiment Station about two and one-half miles, from the reservoir.

Table of Monthly Averages of the Number of Bacteria in a Cubic Centimeter of Water from Different Parts of the Lawrence Water Works.

1891.	Force Main, Pumping Station.	Reservoir.	City Hall Tap.	Experiment Station Tap.
January,	2,872	713	347	72
February,	1,387	224	92	34
March,	890	222	98	33
April,	770	390	190	62
May,	4,030	242	68	49
June,	3,690	192	50	95
July,	5,030	507	219	188
August,	1,920	317	521	181
September,	12,150	262	166	144
October,	12,550	888	975	356
November,	3,576	408	300	122
December,	11,440	2,384	1,215	401
Averages,	5,025	562	353	145

Commencing Sept. 1, 1891, quantitative determinations of the species of bacteria in the water from the several points were regularly made. It is proposed to continue these determinations for a year, to study the seasonal effects. These results, together with the data obtained in 1892, will be discussed in a future report. In a general way, however, it has been learned from the results at hand that there is a gradual reduction in numbers of all species, the species regularly present at the Experiment Station tap being those which were most numerous in the river water. It is of interest, in connection with the investigation upon Filter Tank No. 8, to note the percentage which *B. coli communis* formed of the total number of bacteria at different points (September to December, inclusive).

	Number of Determinations.	Average Total Bacteria per Cubic Centimeter.	Average Coli Communis per Cubic Centimeter.	Per Cent. of Coli Communis.
Pumping station,	7	12,600	110	9
Reservoir,	6	576	93	11
City Hall tap,	6	505	138	16
Experiment Station tap,	12	238	28	27

This table is composed of results which are averages of fewer determinations than those underlying the table above, and the numbers, therefore, are not identical. The data presented, however,

show very clearly that *B. coli communis* is a very persistent organism; in fact, of the prevailing species of bacteria in the water of the Merrimack River at Lawrence, it appears to be one of the last to disappear.

This fact, in connection with the data showing that *B. coli communis* is totally removed from the river water during the passage of the latter through Filter Tank No. 8, confirms the important conclusion that with the filtering materials and rate of filtration of this filter it is possible to remove all bacteria from the water of the Merrimack River by intermittent filtration.

THE DIFFERENTIATION

OF THE

BACILLUS OF TYPHOID FEVER.

By George W. Fuller, S.B.,
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THE DIFFERENTIATION OF THE BACILLUS OF TYPHOID FEVER.*

For several years it was believed that the most marked and sufficiently diagnostic characteristic of the typhoid fever bacillus was its growth on sterilized potato. In two days at blood temperature, or in three to four days at room temperature, the inoculated potato gives a luxuriant, but to the unaided eye completely invisible, growth. The entire surface assumes a moist, shining appearance, but is not otherwise changed. If a small portion of the surface is removed with a sterilized platinum needle, and examined in a drop of water under the microscope, a large number of bacilli are to be seen moving about very energetically. It was thought for some time that this was a means of differentiation from all other species of bacteria. The results of many months' work in this laboratory, however, confirm the conclusion of several investigators abroad which have indicated that this is not the case, and for two reasons: first, because the typhoid bacillus does not invariably give this invisible growth; and, second, because there are several species very similar to the typhoid bacillus in their growth on the usual culture media, which under some circumstances present the same appearance when grown on sterilized potato. Of these so-called "pseudo-typhoid" bacilli there are at least five species in the water of the Merrimack River at Lawrence. Like other observers, I have found that this characteristic of the typhoid bacillus is obtained only when the potato is slightly acid; slightly alkaline potato giving a gray or yellowish growth along the inoculation line. Moreover, as different specimens of potato appear to vary in their acidity or alkalinity, and as the same variety changes in this respect during the different

* This paper appeared in the "Boston Medical and Surgical Journal," Sept. 1, 1892.

seasons of the year, the potato test is not only to be no longer considered diagnostic, it is often contradictory.

At the Lawrence Experiment Station of the State Board of Health, under the direction of Mr. Hiram F. Mills, many experiments have been made upon the life-history of the typhoid fever bacillus in milk and in water, and upon the possibility of its passage through sand filters. Realizing the uncertainty of the differentiation of this micro-organism by means of the potato test, a comparative study of the different species of bacteria in the water of the Merrimack River at Lawrence, of which there are more than thirty, was systematically undertaken side by side with cultures of the typhoid bacillus. To this end it became necessary to make a thorough investigation of the typhoid bacillus itself. The numerous special methods and media proposed for its differentiation were studied, and their diagnostic value ascertained. The observations of its characteristics and its behavior upon the various culture media now employed in this laboratory are as follows: —

Morphology. — When grown on agar in tubes for one week at 20° C., it appears to be a plump bacillus, with rounded ends, about 1μ long and 0.6–0.8μ in diameter. When grown in bouillon at blood temperature for two days it is a bacillus 1.5–2.5μ long and 0.5–0.6μ in diameter. Spore formation and involution forms under the above conditions have never been observed. Hanging drop preparations from bouillon cultures, at blood temperature, show that the bacilli possess very lively movements both of rotation and translation. The motility of the bacilli, when taken from agar cultures grown at blood temperature, is very constant but somewhat less marked; but from agar cultures grown at 20° C. it is not only less marked but it is not uniformly present.

While the motility of the typhoid bacillus is one of its most marked characteristics and is an essential number in the series of characteristics which enables the bacteriologist to identify this micro-organism, yet in water, sewage and other sources are found species of bacteria which possess this characteristic to a very similar degree. Moreover, it has been learned from the repeated determinations of the species of bacteria in numerous samples of water that an element of variability in the morphological appearances of bacteria arises when cultures are grown on media of different composition, of different degrees of alkalinity, for different periods of time, at different temperatures. Accordingly, in order to make microscopical

observations of value, a standard method of procedure should be adopted, making all conditions as nearly parallel as possible.

Relation to Temperature. — The typhoid bacillus can be grown in culture media at temperatures varying from 10° C. to 45.5° C. Its optimum temperature lies between 37° C. and 39° C. It has been found that at the extreme limits of temperature the bacillus grows better in liquid than in solid culture media.

Description of Growth on the Different Culture Media. — On the gelatine plate the bacillus grows and forms colonies in the usual time, namely, forty-eight to seventy-two hours, at 20° C. The colonies lying deep in the gelatine are small, white, spherical or spindle-shaped and sharply outlined. Those on the surface are larger, bluish-white, with slightly irregular outline; under the microscope the colonies often appear to have ridges or folds. In some cases a centre is visible, but it is the exception. The gelatine is never liquefied. It was thought at one time that the typhoid colony was very characteristic, with its yellowish centre and bluish veil of irregular outline with ridges like the veining of a leaf. It is now known that the colony does not always present this characteristic appearance, and, further, that there are several species of bacteria in water which cannot be distinguished from the typhoid bacillus by their growth on the gelatine plate.

When grown in a gelatine tube, a moderately conspicuous, gray growth appears along the inoculation line, while at the surface there is a thin, gray skin of irregular outline which spreads toward the wall of the tube.

On the agar plate, incubated at 38° C., the surface colonies are slightly irregular, bluish-white, sometimes having a white centre. Those below the surface appear yellowish-white and are usually oval. On the inclined agar tube the typhoid bacillus gives a well-defined, smooth, moist, grayish growth.

When grown in sterilized milk the typhoid bacillus produces no coagulation and but a very slight amount of acid. It is not possible to detect the acid with litmus, but with phenolphthalein, which is a more delicate indicator than litmus for organic acids, it can be shown that a slight acid fermentation probably takes place. The milk test is manipulated as follows: The milk, drawn fresh from the cow and as nearly sterile as possible, is taken at once to the laboratory, tubed and sterilized, five cubic centimeters being carefully measured into each test-tube. The tubes are sterilized for three-quarters

of an hour on three successive days. From time to time the apparatus and doubtless the atmosphere of the laboratory contain spore-forming bacteria, which are killed with great difficulty at steam temperature. Notwithstanding the precautions mentioned above, I have frequently found that some of the tubes of milk were not sterile. It was also observed that the species which were not killed at steam temperature produced coagulation. Accordingly, after the tubes have been sterilized three times they are placed in a thermostat at 38° C. for twenty-four hours. After another sterilization the tubes which had a growth in them are found to be coagulated and are discarded. Although many weeks may go by without having difficulty in this direction, the satisfaction of having sterile milk, and of knowing that it is such, well repays the additional labor.

The tubes are inoculated and the cultures allowed to grow for two days at 38° C., or for four days at 20° C. At the end of this time they are examined for coagulation, after which they are placed in boiling water for five minutes, and the coagulation, if any, again noted. The second observation gives uniformly constant results for the same species, whereas, before boiling, the coagulation by many species is sometimes positive and sometimes negative even after they have grown in the milk for a much longer time. The great advantage of this procedure is well illustrated in the case of the *Bacillus coli communis*, which ordinarily takes from two to seven days to coagulate milk. If, however, a culture is allowed to grow for twelve hours at 38° C., and is then placed in boiling water, coagulation at once follows. In explanation of this fact it is to be remembered that the caseine of milk is precipitated by acid (and redissolved by alkali) and that it is coagulated by heat in the presence of acid; therefore, in some cases, probably, the acid, although unable to precipitate the caseine, is sufficient to coagulate it in the presence of heat. The facts, however, that in some cases a small amount of acid effects precipitation before heating, while in other cases a comparatively large amount of acid produces no coagulation after prolonged heating, point to further chemical changes.

After the coagulation has been tested, the milk is placed in an evaporating dish and the amount of acid determined by titration against a twentieth-normal solution of caustic potash, using phenolphthalein as the indicator. As is well known, normal milk is acid with this indicator, the five cubic centimeters of milk requiring about two cubic centimeters of a twentieth-normal solution of caustic

potash for neutralization. This blank, which is determined for each lot of milk, is of course deducted from the amount of caustic potash required to neutralize each tube of milk after the bacteria have grown in it. It will be readily seen that there is a great advantage in using this indicator, inasmuch as the blank is sufficiently acid to enable alkali, if present to a moderate extent, to be estimated as well as if the fermentation had been an acid one.

When grown in a peptone solution containing potassium nitrate, the typhoid bacillus reduces the nitrate to nitrite. The explanation of this fact seems to be that, among the decomposition products of the peptone, some reducing agent or agents are formed, the nitrate being used simply as an indicator. It is not clearly known what the reducing agents are, but the test is of great value to the bacteriologist, as the statements of Heræus, Frankland and Jordan have suggested. After many hundreds of trials upon the typhoid bacillus, the test has never been known to fail if made with proper manipulation. This method is also of great service in the differentiation of other species, as from the single test three possibilities may result: —

(1) The nitrate may remain as such. (2) It may be reduced to nitrite. (3) It may be reduced completely; that is, to ammonia or to free nitrogen.

The solution is prepared by dissolving one gramme of peptone and two-tenths of a gramme of potassium nitrate in one litre of city water. The reason that this water is used rather than distilled water is because it contains the phosphates and other inorganic salts which appear to be necessary for the growth of the bacteria. The solution is rendered alkaline to the same degree as ordinary nutrient gelatine, tubed, sterilized, inoculated, and the bacteria are allowed to grow for one week at 20° C. To determine in what condition the nitrogen is present, after the growth of the bacteria, a test for nitrites is first made. A cubic centimeter of the solution is removed to a clean test-tube, containing about ten cubic centimeters of distilled water free from nitrites. One cubic centimeter each of strongly acid sulphonilic acid and of napthylamine hydrochlorate solution are added; and nitrites, if present, are indicated by a pink color. If nitrites are present, then the determination is sufficient; but, if they are absent, a determination of nitrates must be made, in order to learn, by their absence or presence, whether there has been a complete reduction, or none at all. To make the nitrate determination, the tube containing the solution is inverted and the small

amount of solution remaining is evaporated to dryness. Phenolsulphonic acid, water and caustic soda are successively added, and the presence of nitrates is indicated by the production of a yellow color.

For some time it has been known that the presence of glucose enables facultative anaërobes to grow luxuriantly in the absence of oxygen. Taking advantage of this fact, Dr. Theobald Smith* of Washington has devised a method which we have found to be of the greatest value for the diagnosis of the typhoid bacillus. The solution used contains two per cent. glucose, one per cent. peptone, five-tenths per cent. common salt, and is rendered alkaline to the same degree as the nutrient gelatine used in this laboratory. In place of the U tubes, such as are used in the determination of sugar in urine, recommended by Smith, small test-tubes bent have been found to answer the purpose very nicely. The tubes are bent at about one inch from the closed end, forming an interior angle of 75°. The solution is poured into the tube till the closed arm is filled and there stands about a half-inch in the open one. The tube is plugged, placed in a wire basket so that the closed arm will be in an inclined position, and sterilized in the usual manner. After boiling, the air in the closed arm rises to the upper end and must be removed at once to prevent reabsorption. The tubes are again placed in a basket, after inoculation, so that the closed arm shall be in an inclined position.

There are three ways, as Smith has shown, in which bacteria may grow in this tube: (1) Obligate aërobes, and facultative anaërobes which are not motile, do not grow at all in the closed arm. (2) Facultative anaërobes which are motile grow into the closed arm and produce a turbidity. The typhoid fever bacillus is an example of this class. (3) Some facultative anaërobes, which are motile, grow into the closed arm, producing a turbidity as do the last class, but they also liberate gas. *Bacillus coli communis* is an example.

This test has been found to be of special value in this laboratory, as there are very few non-liquefying bacteria present in the water of the Merrimack River which belong to the same class as the typhoid bacillus.

The observations obtained from the above tests, taken together, have proved sufficient to differentiate the typhoid bacillus beyond all reasonable doubt from every species of bacteria yet met with in

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* Centralblatt für Bakteriologie, Bd. VII., p. 502; *Ibid.*, Bd. XI., p. 367.

the water of the Merrimack River at Lawrence. By these means, also, there was isolated from the fæces of a patient sick with a typical case of typhoid fever at the Lawrence General Hospital, a bacillus which, after long study, appeared to be in every way identical in its behavior upon culture media with typhoid fever cultures obtained from Prudden of New York and from Chantemesse of Paris. The fæces were passed on the fifth day of the patient's illness. In the course of these investigations eleven examinations of typhoid fæces and three of typhoid urine were made in which the specific organism could not be found.

Of the various other special culture methods and media which have been suggested for the diagnosis of the typhoid bacillus, none have proved to be of sufficient value to warrant them a position in the scheme for the differentiation of this bacillus. This does not necessarily indicate, however, that these special methods and media are valueless when working with waters differing from the Merrimack River in their flora, nor is it claimed that the observations outlined above are sufficient to differentiate absolutely the typhoid bacillus from all other species of bacteria.

The work of many months goes to show that before any degree of certainty can be reached in the identification of the typhoid bacillus a thorough knowledge must be had of the ordinary species of bacteria present in the source under examination. Until recently the potato test was used to differentiate the *Bacillus coli communis* from the typhoid bacillus. At the present time, after careful work by several investigators, it has been found that this test is untrustworthy, and in its place there are, as is well known, three apparently unfailing tests, namely: (1) when grown in sterilized milk the *Bacillus coli communis* produces coagulation, — the typhoid bacillus does not; (2) in sterilized milk the *Bacillus coli communis* forms acids, — the typhoid bacillus forms a very slight amount or none; (3) in the Smith test the colon bacillus forms a turbidity with gas, — the typhoid bacillus a turbidity without gas. (Both bacilli reduce nitrate to nitrite in a peptone solution.)

In obtaining a knowledge of the species of bacteria in the source under examination, an opportunity is afforded to ascertain the limits of accuracy of the methods employed. It will also appear if there are any species regularly present which are identical, within the limits of variability, with the typhoid bacillus in all the tests employed. If such species are present, then new methods for differ-

entiation must be devised; if they are absent, there can be developed, from a classification of the data, a scheme of procedure which will enable the typhoid bacillus to be most readily differentiated. Thus it has been learned, after frequent examinations covering considerably more than a year and involving more than twenty-four hundred species determinations, that there appear to be no other non-liquefying bacteria in the water of the Merrimack River which coagulate milk and also produce a turbidity, without gas, in the Smith test. Accordingly, when a sample of this water is to be examined for the typhoid bacillus, "fishes" are made from the non-liquefying colonies upon the gelatine plate into Smith tubes. Those cultures which produce a turbidity, without gas, are transferred to milk and to the gelatine tube. From the data thus obtained those species which are not typhoid are readily thrown out, while typhoid bacilli may be subsequently passed through all the tests described above, and their identity confirmed.

Much labor can be saved by the use of the agar, instead of the gelatine plate culture, grown at 38° C., which is the optimum temperature for the typhoid fever bacillus, but is so high as to inhibit the growth of many water species.

Summary.

1. After prolonged investigation, it has been found that it is possible to separate the bacillus of typhoid fever from all other bacteria hitherto encountered in the water of the Merrimack River.

2. The potato method of differentiation is for this organism of no diagnostic value.

3. The three tests which have been found to be highly characteristic of the bacillus of typhoid fever are (after non-liquefaction): (1) non-coagulation of milk; (2) non-formation, or formation of a very slight amount, of acid in milk; (3) production of a turbidity, without gas, in the Smith test.

In closing, the writer wishes to express his obligations to Prof. W. T. Sedgwick and Mr. Allen Hazen for many valuable suggestions.

ON UROGLENA,

A GENUS OF COLONY-BUILDING INFUSORIA OBSERVED IN CERTAIN WATER SUP-PIIES OF MASSACHUSETTS.

BY

GARY N. CALKINS,

Assistant Biologist of the Board.

ON UROGLENA,

A GENUS OF COLONY-BUILDING INFUSORIA OBSERVED IN CERTAIN WATER SUPPLIES OF MASSACHUSETTS.

[With Plates I-IV.]

From time to time there has been observed in some of the water supplies of Massachusetts a peculiar organism barely visible to the naked eye, globular in form, greenish-yellow in color, and, on superficial examination, closely resembling *Volvox Globator*. More recently this organism has appeared in great abundance in the water supplies of Norwood and Plymouth, and, while not accompanied by any marked odor in the ponds or reservoirs, it was associated with a most objectionable odor in the corresponding tap waters. A careful examination soon showed the organism which had thus suddenly appeared, to be a colony-forming infusorian belonging to the genus *Uroglena* of Ehrenberg, a form almost unknown in America and only very recently suspected of doing damage to water supplies. Advantage was at once taken of the unusual opportunity to make a thorough study of this unfamiliar organism, and the results of this study appear in the following pages.

I desire at the outset to acknowledge my indebtedness to Professor Sedgwick, whose suggestions and friendly advice have been of invaluable assistance to me in the preparation of the following paper.

From the biological point of view, *Uroglena* is of great interest on account of its rarity and its colony-building habit; while from the practical point of view, its novelty and efficiency as a producer of offensive odor and taste in water supplies, give to it special importance. It will be shown in the sequel that in this respect it is peculiar, since it appears to liberate odoriferous materials by disintegrating, instead of generating odors by its decay. That is, its odor appears to be one of disintegration rather than of decomposition. Another peculiarity is that water taken from a pond or reservoir may be

crowded with colonies of *Uroglena*, and yet emit no objectionable odor; while the tap water from pipes served by this supply may contain no colonies of *Uroglena*, and yet emit a most disagreeable, oily odor. It seems probable that *Uroglena* is not really rare, but it usually occurs in clear waters which are seldom examined by microscopists, and the rapid disintegration of its colonies during transportation may have caused it to be overlooked.

I. History.

The genus *Uroglena*, including the single species *Volvox*, was established by Ehrenberg * in 1833. It is figured and described in his great work on the Infusoria.† It appears to have been overlooked by subsequent workers until 1878, when Bütschli,‡ finding *Uroglena* in moderate abundance near Carlsruhe, made a careful study of it. In the same year Stein included it in his work on the Infusoria; § while in 1881 W. Saville Kent, in his well-known treatise, || devoted much space to *Uroglena*, and made numerous original observations upon it.

All of these authors describe the genus as consisting of one species only, — *Uroglena Volvox* of Ehrenberg. Bütschli, in his revision of the Protozoa, establishes for *Uroglena* a sub-family, the *Uroglenince*, which includes but one genus, *Uroglena*, and only one species, *Volvox*.

From the fact that so large and conspicuous an organism was not mentioned in the forty years between 1838 and 1878, it would appear that, unless it was overlooked, it was scarce in Europe. Perty and Dujardin, as well as Fromentel, appear to have quite neglected it, for in their works there is no mention of *Uroglena Volvox*. Bütschli, however, does not admit that *Uroglena Volvox* is rare, and even considers it common. Kent does not state whether it is common or rare, although he mentions the fact that his samples were sent to him.

Whether scarce or not in Europe, *Uroglena* has appeared a dozen times or more during the last three years in the public water

* Abhandlungen der Berlin. Akademie. 1833.
† Die Infusionsthiere als vollkomne Organismen. Leipzig, 1838.
‡ Zeitschrift für Wissenschaftliche Zoologie. 1878, Bd. XXX., p. 265.
§ Organismus der Infusionsthiere, III. 1878.
|| Manual of the Infusoria, I. London, 1881.

supplies of Massachusetts and Connecticut. A curious fact in regard to its appearance in America is that it has been observed chiefly in public water supplies. We believe, that in many of these cases, it was the presence of *Uroglena* which rendered the water unfit for drinking because of the disagreeable odor and taste. Four conspicuous instances of such trouble with water are those of Middletown and Meriden in Connecticut, and Norwood and Plymouth in Massachusetts.

Uroglena appears to have been first recognized in America by Conn,* who at first mistook it for *Volvox*. It appeared in great quantities in the reservoir of the water works of Middletown, Connecticut, in June, 1889, and presented the peculiar characteristics of enormous development in the reservoir, and absence from the tap water. The water from the reservoir was free from odor but the tap water was most objectionable.

It appeared in the service reservoir of a neighboring city, Meriden, Connecticut, in the autumn of the same year, showing similar peculiarities. It was at first supposed by Williston, who investigated it, to be *Volvox*, but he afterwards identified it as *Uroglena*, and drew attention to its occurrence by a note in the "Microscope," for March, 1890. †

In the course of the regular microscopical examinations of the drinking waters of Massachusetts, forms have been frequently observed during the last two years which were supposed to be *Uroglena Volvox* (Ehbg.) and reported as such. The organisms did not appear in sufficient numbers, however, to require special study, until February, 1892. In this month they began to infest Buckmaster Pond in Norwood, until there were as many as 1,300 of the yellowish spinning spheroids in every cubic centimeter of the water. This growth lasted until the middle of June, and, during most of the time, weekly examinations of the water were made. At the same time the water of Little South Pond in Plymouth became infested with the same organism. In both of these cases the appearance of *Uroglena* was accompanied, as it is said to have been in Middletown and Meriden, by a distinct, peculiar and disagreeable odor and taste.

Specimens of *Uroglena* have been observed also in other water

* Report of the Water Commissioners for 1889, Middletown, Conn.

† Report of the State Board of Health of Connecticut for 1891, page 394. See also Report of Smith, in the same volume, page 384.

supplies of Massachusetts; but the organisms have been found to differ to such an extent from those in Norwood and Plymouth that a detailed description of each kind observed is required. It is particularly interesting to observe that there appears to be also a difference between the several kinds in respect to their power of producing odors in water, a fact which points to important and fundamental physiological differences.

II. The Colonies.

Uroglena, as found in Massachusetts, exhibits well-marked species. In all cases, however, the colony forms are similar, and a description of one may suffice for all.

The colony is visible to the naked eye (about $\frac{1}{125}''$ in diameter), but with a hand lens it can be more clearly made out as a minute globular body swimming in the water with a slow and spinning motion. An objective of low power reveals the characteristic features of the colony, and shows it to be a beautiful spheroid, superficially resembling *Volvox Globator*. A very brief examination, however, is sufficient to show that it is quite different from *Volvox*, being composed of a colorless and transparent globe of jelly studded with yellowish-brown monads or zooids. (Pl. I., Fig. 1, and Pl. IV., Fig. 1.)

Prolonged investigation has led me to the following conclusions concerning the structure of these globoidal colonies. They consist of spheroidal bags or bladders of colorless, transparent and watery jelly, filled, at least in some cases, with a more fluid substance. The jelly-like shell is relatively thin, and bears in its thickness a somewhat larger proportion to the whole mass than an egg-shell bears to an egg. Imbedded in this jelly-like shell, and separated from each other by intervals varying from one to three times their own diameter, are the living monads. Two unequal flagella protrude from each monad, and these give to the whole mass a motion like that of a ball slowly spinning on its axis, or that of a top which, while it spins, is also moving forward. The evidence that some colonies contain a central fluid is drawn from the fact that organisms have been repeatedly observed by us within the spheroid, travelling about with apparent ease. The colonies are so soft that they lose their form when they are stranded and left partly exposed to the air, that is, they flatten and collapse of their own weight. A coverslip

easily crushes them, and when they are thus crushed the monads are pressed out, and either mingle with the jelly in a confused mass, or arrange themselves in circles. (Pl. II., Fig. 1.) The colonies vary in size from 200 to 360 microns, the average diameter of the Norwood specimens being 275 microns.

Ehrenberg, by describing the "studded coating of the colony," indicates that he perhaps regarded the gelatinous layer as enclosing an inner substance. Bütschli affirms that the contents are evidently fluid, as he has observed organisms swimming about within the globe. Stein, on the other hand, regards the gelatinous globe as homogeneous. It will be observed that my observations confirm those of Ehrenberg and Bütschli.

Broken masses of colonies are frequently seen, reminding one in their shape, of broken egg-shells. Pieces with only one or two monads have been seen travelling about, their flagella being in active motion. While these facts alone might warrant the assumption that reproduction of the colony takes place by division, we have been so fortunate as to actually observe the process. When first noticed, the colony, moving slowly and as if uncertain which way to turn, measured about 360 microns in diameter, and presented a flattened appearance with a minute yet distinct furrow on one side. This furrow gradually increased in depth, until finally the two portions were connected by a mere band of monads and jelly. In this condition one part would revolve in one direction while the other part turned in the opposite direction, thus giving the connecting band of jelly a considerable wrench or twist. In about thirty minutes after the first observation the two portions had entirely separated and moved apart, each with a much more rapid motion than that of the original colony.

This division of the colony cannot be considered to be of the same character as that of simple protoplasmic forms. It is rather the result of mechanical forces acting in different directions, thus literally twisting the large colony mass into two separate portions. It is not a division due to the inherent power of the colony-protoplasm to divide. A large colony is an unwieldy mass to revolve, and moves only when the vibrations of the flagella are more or less synchronous. If the vibrations in one part of the colony become inharmonious with the rest, there is a tendency for the different parts to move in different directions, and if the opposing forces are greater than the power of cohesion of the jelly mass, the colony is ruptured.

After complete separation, the broken edges of each part come together and form two spherical or spheroidal colonies, each similar to the original. Colony division appears to be, therefore, a physical rather than a biological phenomenon, and yet it probably plays an important part in the multiplication of *Uroglena*. It has not been detected by earlier observers.

In all colonies there are from two to ten larger spherical cells, several times as large as the individual monads. These have a hard cortical layer, and contain bright green spherules which are in some cases so abundant as to fill the cell. (Pl. IV., Fig. 3.) The tough skin of these bodies enables them to withstand the action of acetic acid and of stains. They have not been observed by us to play any part in the process of reproduction, but they resemble reproductive bodies, or their function may be, as Kent suggests, to preserve the species during long seasons of drought.

In some colonies the whole mass is clear and transparent (Pl. IV., Fig. 1), in others there appear to be minute rounded particles which arrange themselves radially, giving to a section of a colony the appearance of a spoked wheel. (Pl. III., Fig. 1.) In still others there are external, foreign and apparently symbiotic forms which surround each monad concentrically, and which lose their circular arrangement on disruption of the colony. (Pl. I., Fig. 1; also Pl. II., Fig. 1.)

In different species of *Uroglena* there are different degrees of resistance in the colonies. Some disintegrate immediately upon derangement of their customary environment, others only after considerable time, and we have already indicated that there appears to be a difference in colonies in regard to the production of odor and taste in water.

III. The Monads.

While the colony forms of *Uroglena* in the different species in Massachusetts are much alike, the monads are very different. There appear to be at least three separate and well-defined types of the individual monads, although they all possess the characteristics of the sub-family *Uroglenina* and the genus *Uroglena*, as laid down by Bütschli in his well-known work on the Protozoa. The flagella are always two in number, one several times longer than the other. At the base of the long flagellum is a large red eye-spot slightly protruding from the periphery. The pigment plates are two in number, but frequently so closely joined that it is impossible to distinguish them as two. Nuclei have been observed in some specimens, but not in

all. In some cases a large ovate amylaceous body is quite conspicuous. The three types referred to were not found together nor in the same locality, but appeared in widely separated sources of water supply, and for each source the particular form was constant. The principal localities were a storage reservoir at South Hadley Falls, an artificial reservoir at Holyoke and natural ponds in Norwood and Plymouth.

A. Uroglena radiata, n. sp. (*U. Volvox*, Ehbg.?)

At first sight this colony-form suggests Ehrenberg's description of *Uroglena Volvox*. Each colony has a radiating structure from the centre outwards as far as the jelly mantle, showing that, in these cases at least, the spheres are not simply hollow, and also that the structure is not homogeneous throughout. (Compare Pl. III., Fig. 1.) On more careful examination, however, it is seen that these rays are not in the least similar to the stalks of *Vorticella*, to which Ehrenberg compares the posterior prolongations of the monads, and which, according to him, unite in the centre of the globe. They appear somewhat filiform, but suggest merely the paths or wakes of monads in a gradual change from their position in the colony when it was small to their position on the periphery of the enlarged colony.

This species is of special interest, because the question has been raised whether the monads of *Uroglena Volvox* are stalked or sessile. Ehrenberg, as has just been said, describes them as furnished with thread-like processes at the posterior end, similar to the stalks of *Vorticella*. Bütschli failed to find these processes, and doubts their existence. Stein makes no mention of their existence, but Kent's description closely follows that of Ehrenberg. As is shown by our figure, there is in this species a constant radial structure of the colony, but the rays cannot be said to resemble the stalks of *Vorticella*, and even these are entirely wanting in the other species that have come under our observation. I am disposed to regard this species as similar to, though not identical with, that observed by Ehrenberg and Kent, but very different from that observed by Bütschli.

The monads in this species are similar to the individuals figured by Ehrenberg. (Pl. III., Fig. 3, a monad of *Uroglena radiata*, from South Hadley Falls; Fig. 4, a monad from colony o *Uroglena Volvox* after Ehrenberg.) The chromatophores are two in number and are arranged on opposite sides of the body. In the centre and between the chromatophores lies the nucleus. Contrac-

tile vacuoles not observed. The posterior end is drawn out into a hyaline pointed process. There is one red eye-spot situated at the base of the long flagellum. Length of the monads, from 10 to 12 microns; breadth, 5 microns; length of flagella, 15 and 5 microns respectively. This form appears to produce no odor in water.

B. Uroglena Volvox, Bütschli. (non Ehbg.)

The colonies of *Uroglena* from Whiting Street Reservoir, Holyoke, were smaller and more active than any we had seen before. On examination with a low power, each colony appeared to be composed of monads similar to those observed in the specimens just described. The most striking superficial difference, however, was the presence in these specimens of minute bodies which seemed to be arranged concentrically about each monad. (Pl. I., Fig. 1.) In size and shape these bodies resembled certain bacterial forms, but the color (a bluish-green) excludes them from this group. (Pl. II., Fig. 2.) They were about 4 microns long and 1.5 microns broad. No cilia and no appendages of any kind were observed, but they were seen to move about whenever the colony mass was subjected to pressure. This motion was probably due to the current made by the contents of the spheroid passing out between the individual monads.

The colonies when subjected to sudden pressure of the cover glass invariably separate into small rings, of which each colony forms from two to eight. The circumference of each ring is beset with monads. (Pl. II., Fig. 1.) The small blue-green bodies never remain inside of these rings, but always gather around the monads outside of the circumference. In three or four minutes after the formation of the rings the monads in the circumference separate, and the original colony is left as an amorphous mass. The motion of each individual as it breaks away from its fellows in the ring is quite characteristic. The flagella are observed to be in active motion, when suddenly something seems to give way, and the monad darts forward with an impetus which carries it away from the old position to a distance about equal to its own length. It then loses its original shape and forms a minute sphere, while the chromatophores form two greenish-yellow globular masses in the interior. (Pl. II., Fig. 5.)

A somewhat different result is obtained by a slow, steady pressure of the coverslip. By this the colony is reduced to one rather large ring of monads; this disintegrates rapidly, and the blue-green bodies

collect around the outside as before. This peculiar circular arrangement of the monads under pressure is very characteristic of the Holyoke species of *Uroglena*. Colonies from South Hadley Falls and other places act in an entirely different manner. These, when either suddenly or gradually crushed, merely break up into amorphous masses of individuals.

The monads of the Holyoke species are long (10 to 12 microns) and have broad rounded ends. The posterior end is not extended into an hyaline spike, nor are there tail-like processes uniting in the centre of the colony. The chromatophores are two in number, but not clearly defined. The nucleus is situated at the posterior end of the chromatophores and between them. There is one red eye-spot at the base of the long flagellum. The flagella are two in number and of unequal length (18 and 4 microns respectively). (Pl. II., Figs. 3 and 4; compare also Pl. III., Fig. 2.) Sporocysts, from one to eight in number, occur in each colony. No odor in water appears to have been produced by this species.

C. Uroglena Americana, n. sp.

The Norwood and Plymouth species of *Uroglena*, which appear to be identical, impart a peculiar and disagreeable odor to the water, and in this as well as in other respects this species is different from the forms already described. The odor, which is not noticeable in samples taken fresh from the ponds, becomes very distinct and unpleasant when the samples stand for some time. The taste is distinctly oily, and suggestive of fish. The Norwood and Plymouth colonies of *Uroglena* disintegrate very readily upon the least change in the conditions surrounding them. Further investigation has shown that the monads composing the colonies also disintegrate shortly after the colonies break up. Each monad seems to possess one or more minute oil-like globules, which in several cases were seen to exude from the mass after disintegration of the individual. An attempt was made to study this oil-like substance by concentrating a great number of colonies and treating them with gasoline and ether. Upon evaporation of the water and gasoline the watch glasses used, were found to be covered with a distinct oil-like coating, which gave off an intensely strong and disagreeable odor. From these facts, together with the absence of any evidence of decomposition, as shown by bacterial and chemical analyses, we may perhaps conclude that the

odor and the taste observed in the water were due to the liberation of an oil contained in the individual monads and not to their decay.

Upon crushing the colonies with a coverslip, the monads separate and form an amorphous mass with the jelly. There is no indication of a consistency sufficient to enable the monads to form rings, as in specimens of *Uroglena Volvox*. Reproduction of the colony by division, as already described, was observed in this form. After division of the colony, portions might be seen with ragged edges resembling broken egg-shells. We have not seen these portions of colonies develop into complete globes, as we were unable to preserve the specimens for a sufficient length of time; but it is probable that, under favorable conditions, the colony is completed and rounded by continued division of the monads.

Although division of the monads was not observed, cells were seen inside of the colony stocks showing different stages in a process of division. This may have been a formation of sporocysts rather than of new monads. (These stages are figured on Pl. IV., Fig. 4, A, B, C, D and E.) Kent states that the individuals may divide into eight, but we have not observed this stage. Monads were also seen to swim about inside of the colony, but whether these were new forms or old monads withdrawn from the periphery was not determined.

The monads in the Norwood variety are spherical in form, and measure from 5 to 7 microns in diameter. The ends are not rounded or pointed, as Bütschli describes them in *Uroglena Volvox*, nor are there tails or stalks, such as are described for the latter by Ehrenberg and Kent. There are two flagella, the principal one 13 microns in length, the other, or associate flagellum, only 2. Motion of the chief flagellum is undulatory. Each monad bears one red eye-spot, oval in shape and situated close to the base of the long flagellum. (Pl. IV., Fig. 2.) Each cell contains a nucleus, vacuoles and pigment plates. The chromatophores appear to be undivided in some cases, or, if divided, the parts are so closely joined together that they cannot be distinguished. In such cases the chlorophyl seems to form a sac in which the nucleus lies. Vacuoles (usually two, non-contractile) are placed without order in the cell.

From what has now been shown, it is evident that *Uroglena* is not rare in Massachusetts, and that it appears in well-defined species. It appears to us that in Europe also there is probably more than one species, and that this fact accounts for the different characteristics assigned by Ehrenberg, Bütschli and Kent to *Uroglena Volvox*. We have hesitated to propose new species. But, while we have unquestionably been dealing with *Uroglena*, we have not been able to identify any of our species with *Uroglena Volvox* of Ehrenberg or of Kent. One form is apparently identical with *Uroglena Volvox* as described by Bütschli in 1878, but the others differ from this and from each other so widely as to demand complete separation.

It is interesting to remark that, while superficially resembling *Volvox*, *Uroglena* differs from it entirely. The monads appear to be in *Uroglena* wholly distinct one from another; the two flagella are unequal; and, most important of all, there appears to be no indication whatever of sex such as *Volvox* exhibits. The endogonidia or sporocysts, it is true, superficially resemble the highly differentiated sexual bodies of *Volvox*. We have had very unusual opportunities for studying *Uroglena*, but we have never been able to make out in the sporular bodies anything approaching to sexual elements. The division of the colony which Bütschli regards as "not improbable" we have actually observed. It may be added that, having followed for months the abundant development of *Uroglena* in reservoirs, we have never observed the slightest tendency towards development into *Volvox* or any other form. *Uroglena* appears to be unquestionably a distinct genus, of which there are at least three well-marked species, as here indicated.

A more complete account of the odors produced by the disintegration of *Uroglena*, and its occurrence in particular water supplies, will appear in a future report.

PLATE I.

A colony of *Uroglena Volvox*, Bütschli (non Ehbg.), from Whiting Street Reservoir, Holyoke, Mass., showing monads, sporocysts and arrangement of the small blue-green bodies. (x 360.)

PLATE II.

Fig. 1. Portion of the colony represented in Pl. I., showing the circular arrangement of the monads and blue-green bodies, after colony is crushed with a coverslip. (x 360.)

Fig. 2. Blue-green bodies. (x 5500.)

Fig. 3. Monads from colony represented in Pl. I. (x 2000.)

Fig. 4. Side view of monads, showing nucleus lying between the chromatophore plates. (x 2300.) (Compare with Pl. III., Fig. 2.)

Fig. 5. Form assumed by monad after breaking away from its fellows; *chr.*, chromatophore plates. (x 2500.)

PLATE III.

Fig. 1. Optical section of a colony of *Uroglena radiata*, n. sp. (*Uroglena Volvox*, Ehbg.?), from South Hadley Falls, Mass., showing radial structure of the interior. (x 275.) (This figure is drawn from a mounted specimen, and represents the original colony after being crushed with a coverslip.)

Fig. 2. Group of monads from a colony of *Uroglena Volvox*, highly magnified. (After Bütschli.) (Compare with Pl. II., Figs. 3 and 4.)

Fig. 3. Monad from a colony of *Uroglena radiata.* (x 2800.) (Compare with Fig. 4.)

Fig. 4. Monad from a colony of *Uroglena Volvox.* (After Ehbg.) (Compare with Fig. 3.)

PLATE IV.

Fig. 1. Hemispheroid of *Uroglena Americana*, n. sp., from Norwood, Mass. (x 350.)

Fig. 2. Monads from the same colony. (x 2500.) *A* and *F* specimens showing oil-like globules, *F* specimen treated with acetic acid; *B*, *C*, *D* and *E* specimens showing positions of chromatophores and nuclei.

Fig. 3. Sporocysts from a colony of *Uroglena.* (x 2000.)

Fig. 4. Different stages in the division of the monads within the colony. (x 2500.)

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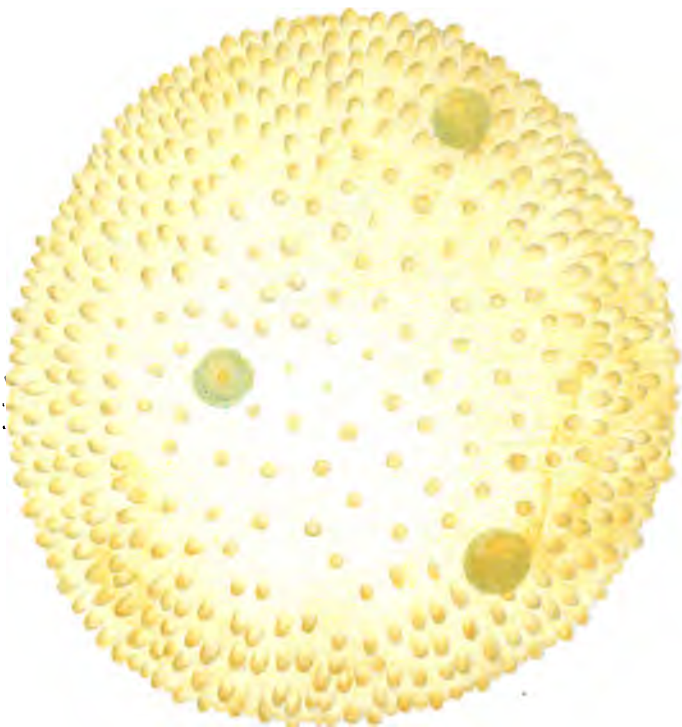

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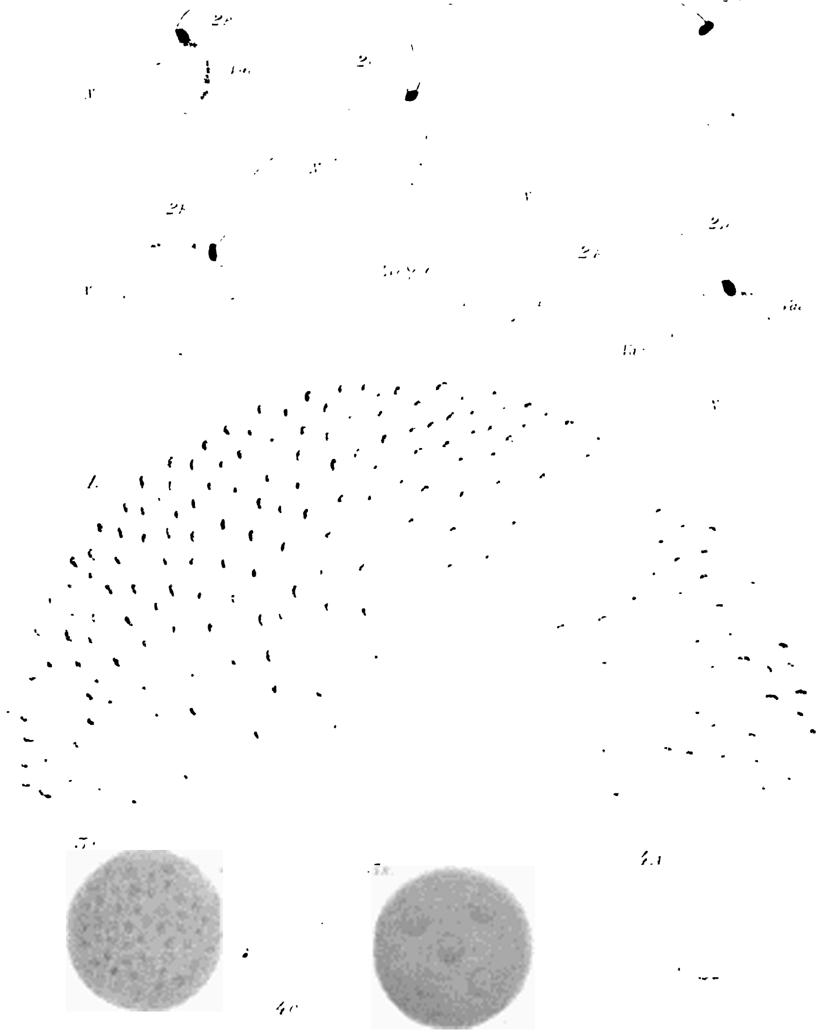


FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The following report comprises a statement of the operations of the Board for the year ending Sept. 30, 1891, under the provisions of the food and drug acts of 1882 and the amendments of later years.

The following analysts and inspectors have constituted the working force of the Board, as in the previous year: —

Dr. BENNETT F. DAVENPORT,	*Analyst.*
Dr. CHARLES HARRINGTON,	*Analyst.*
Prof. CHARLES A. GOESSMANN,	*Analyst.*
Dr. CHARLES P. WORCESTER,	*Analyst.*
JOHN H. TERRY,	*Inspector.*
JOHN F. MCCAFFREY,	*Inspector.*
HORACE F. DAVIS,	*Inspector.*

The number of samples of food and drugs examined during the year was 5,294, making the total number of samples examined under the provisions of the acts relating to food and drug inspection 40,965.

The following summary presents the classified statement in brief of the work done during the year: —

Number of samples of food examined,	4,870
" " " found to be pure,	3,206
" " " adulterated, or not conforming to the statutes,	1,664
Percentage of adulteration,	34.2
Number of samples of milk (included above),	2,726
" " " above standard,	1,629
" " " below standard, or otherwise adulterated,	1,097
Percentage of adulteration,	40.2

Number of samples of drugs,	424
" " " of good quality,	352
" " " not conforming to the statutes,	72
Percentage of adulteration,	17.0

Total examinations of food and drugs,	5,294
" " of good quality,	3,558
" " not conforming to the statutes,	1,736
Percentage of adulteration,	32.8

A further summary is also presented, for the purpose of comparison with the work of previous years: —

SUMMARY.	Years.									Total.
	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	
Number of samples of food examined,	695	1,962	3,771	3,438	4,870	4,904	4,854	5,585	4,870	34,949
" " found to be pure,	363	779	2,180	2,186	3,163	3,385	3,213	3,771	3,206	22,246
" " found to be adulterated, or not conforming to the statutes,	332	1,183	1,591	1,252	1,707	1,519	1,641	1,814	1,664	12,703
Percentage of adulteration,	47.8	60.3	40.3	36.4	35.1	30.9	33.8	32.5	34.2	36.3
Number of samples of milk examined (included above),	218	1,123	2,219	2,085	3,081	2,825	3,219	3,236	2,726	20,732
" " above standard,	35	347	1,297	1,323	1,900	1,705	1,971	1,858	1,629	12,065
" " below standard,	183	776	922	762	1,181	1,120	1,248	1,378	1,097	8,667
Percentage of adulteration,	83.9	69.1	41.7	36.5	38.3	39.6	38.7	42.6	40.2	41.8
Number of samples of drugs examined,	603	682	1,007	888	550	862	600	400	424	6,016
" " of good quality,	357	431	571	463	400	634	503	325	352	4,036
" " adulterated, as defined by the statutes,	246	251	436	425	150	228	97	75	72	1,980
Percentage of adulteration,	40.8	36.8	43.3	47.8	27.3	26.4	16.2	18.7	17.0	32.9
Total examinations of food and drugs,	1,298	2,644	4,778	4,326	5,420	5,766	5,454	5,985	5,294	40,965
" " of good quality,	720	1,210	2,751	2,649	3,563	4,019	3,716	4,096	3,558	26,282
" " not conforming to the statutes,	578	1,434	2,027	1,677	1,857	1,747	1,738	1,889	1,736	14,683
Percentage of adulteration,	44.5	54.2	42.4	38.7	34.3	30.3	31.9	31.5	32.8	35.8
Expense of collection, examination and prosecution,	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$8,915 41	$10,356 28	$10,013 04	$10,019 41	$73,151 69
" " " per sample,	2 26	2 09	1 79	1 85	1 62	1 54	1 89	1 67	1 89	1 79

An increase of the appropriation for this department of the work of the Board, from $10,000 to $11,500, has enabled the Board to enlarge its operations, so that the entire time of three inspectors has been occupied during the latter part of the year in the work ot collecting samples, entering complaints in court, conducting prosecutions against offenders, and such other duties as were assigned to them.

The whole number of samples collected during the year has not been so great as that of 1890, a greater portion than usual of the time of the inspectors having been devoted to the investigation of special cases of food adulteration.

As in former years, the collection and analysis of samples of milk and milk-products occupied a large share of the time both of inspectors and of analysts, as required by the statutes. The justice of this provision of the law is proven by the extreme importance of these articles in the food economy of the population as well as their liability to fraud.

A considerable part of the work of analysis in the earlier years of work has been devoted to the subject of the normal quality of milk as produced by the cow, and a pamphlet published by the Board in 1885, but now out of print, gave the quality of milk as produced by about six hundred cows in the State. The averages of all these showed that the standard adopted by the statute was a little below the general average of animals throughout the State, this general average for total solids being found to be between 13.2 and 13.3 per cent.

A recent published statement of the quality of milk of English dairies very closely confirms the same standard, being slightly lower. Prof. P. Vieth of the British Society of Public Analysts having examined 120,540 samples of dairy milk in the eleven years, 1881–91, found that the average of the whole gave the following result: —

	Per Cent.
Total solids,	12.9
Fat,	4.1
Solids not fat,	8.8

As a general rule, the figures presented by Professor Vieth show that the milk of the first half of the year was slightly below, and that of the last half slightly above, the yearly average. In commenting upon the effect of seasons upon milk, the same writer says: —

A bad season for hay-making is, in my experience, almost invariably followed by a particularly low depression in the quality of milk toward the end of winter. Should the winter be of unusual severity and length, the depression will be still more marked. Long spells of cold and wet, as well as of heat and drought, during the time when cows are kept on pasture, also unfavorably influence the quality, and, I may add, the quantity, of milk.

The foregoing remarks have reference only to milk as regarded from the stand-point of chemical analysis. To a certain extent this view of the subject has a bearing upon the public health, since the addition of water to milk, or the abstraction of cream, impairs its quality as nutriment in proportion to the extent of the adulteration. Strangely enough, the pretence is often urged by milk producers that milk containing 11 or 12 per-cent. of total solids is quite as wholesome or nutritious as that which contains 13 or 14 per cent. of solids. The absurdity of this argument is plain enough, since, if it were true, it might reasonably be asserted that milk having 7 or 8 per cent. of solids is as wholesome as that which has 11 per cent., and so on *ad infinitesimum.*

But, while the statutes take cognizance of this view of the subject, and provide an adequate penalty for the protection of the consumer from this departure from the standard, there are other considerations which are almost wholly neglected by the statutes, and these relate to the conditions which can only be determined by the careful processes of bacteriological analysis, and by a knowledge of the conditions under which milk is produced, prepared for market, stored and transmitted from the producer to the consumer. A thorough discussion of this question has been published by Prof. W. T. Sedgwick, in an address before the Society of Arts, in December, 1891,* entitled, "Milk Supply and Public Health."

In this paper he showed, after several trials, that milk could be drawn from a healthy cow's udder which would be absolutely sterile, that is to say, free from all bacteria. In passing to the consideration of milk as consumed by different classes of people, he goes on to say, with reference to the milk of the country family, at the dairy of production, "pure" milk may possibly be defined as milk which has

* Technology Quarterly, December, 1891, Vol. 4, No. 4, p. 365.

not been watered or adulterated. It is sometimes so defined. But normal milk cannot be defined in this way. Milk drawn from a clean, well-kept Holstein cow, in a good stable, was received into sterilized bottles, and yielded an average of 530 bacteria per cubic centimeter. When an ordinary flaring milk-pail was used, and little care was taken to exclude dust from the stable or from the cow, an average of 30,500 per cubic centimeter was found. Still later, when served upon the table, the same milk was found to contain over 69,000 per cubic centimeter. The stables and the milkmen in these cases were unusually clean.

There are, therefore, two principal sources of contamination in ordinary milk at the dairy of production; namely, contamination during the act of milking, and the natural multiplication of the bacteria thus introduced during the interval between milking and the consumption of the milk. The result of these investigations was to show that even under the most favorable conditions cow's milk as ordinarily drawn becomes almost necessarily infested with hosts of putrefactive bacteria at the very outset. Under worse conditions, with unclean stables and dirty milkmen, to say nothing of half-cleaned pails and cans, it is easy to understand why milk swarms with bacteria; and, if we allow time also, the wonder is not that it contains so many germs, but rather that it is still potable at all. . . . This rich animal fluid, sterile at the start, but drawn by unclean hands into half-cleaned pails, and meantime sprinkled above by the dust of the stable, by hairs, dandruff, dirt and particles of excrement from the skin and udder of the cow, vigorously shaken by the milker or brushed by his hat, becomes infested with organisms. That these multiply swiftly and enormously in the warm, rich fluid, well aerated by the act of milking, is a natural consequence of favorable conditions.

In city milk Professor Sedgwick found an average of 2,355,500 bacteria per cubic centimeter in fifty-seven samples examined in the spring of 1890. The average number of bacteria in sixteen samples collected from groceries was 4,577,000 per cubic centimeter. The milk of groceries is usually older than that which is obtained from wagons. Forty-four samples taken on arrival of milk-cans at railway stations showed an average of over 500,000 per cubic centimeter, the extremes being 5,664,000 and 2,200. These observations were repeated in 1891 with similar results.

With special care milk can be and is regularly delivered in some instances in the city with much greater freshness and purity than the foregoing figures indicate. The two principal conditions which Professor Sedgwick believes, from these investigations, to contribute to the abundance of bacteria in milk delivered for sale in the city are

uncleanness and *staleness*. The former furnishes the seeds of decomposition, the latter the time for their development.

It remains to inquire what is the probable effect of this condition of the milk supply on the health of the community. Here we are very much in the dark. There can be no question that most of the milk is consumed when cooked, and even when raw, without the least apparent injury and with great apparent benefit. But it is probably also true that the use of stale and partially decomposed milk, charged with living bacteria, has its effects upon invalids and children, and particularly upon infants, and that these effects are not always beneficial. It is possible that one explanation of the great mortality of children under five years of age, and especially of bottle-fed children, is to be sought for in this direction. It will not do to argue, because healthy adults drink polluted and stale milk without obvious injury and with evident benefit, that invalids and infants may safely do the same. In order to learn the consequences of a battle, the investigator must examine not merely the survivors; he must consider the fallen. If it be admitted that city infants, children and invalids require normal cow's milk, it cannot be denied that they are now rarely, if ever, fortunate enough to get it. Many parents who are fastidious to the last degree concerning their own wine or table linen, provide for their children cow's milk which is both stale and filthy. It is safe to say that, if our soups or our drinking water were drawn from cows, in remote and obscure stables, by ordinary milkmen, and shipped, manipulated and delivered as our milk supply is, we should appreciate and resent the pollution. At present, however, so far as mere pollution is concerned, it is probably true that milk is actually improved by the addition of pure water. The public inspection of milk in America is usually directed mainly to the prevention of fraud; rarely, if ever, to the question of pollution, or, except in a general way, to the protection of the public health.

With reference to the proper remedy for this condition of an important food supply, Professor Sedgwick continues: "In view of all these facts, we may as well ask ourselves whether, in the place of private care and watchfulness, we have provided any efficient or adequate inspection of the stables from which the milk supply comes, or any even approximately adequate supervision of it after its arrival. There is at present, so far as I am aware, no systematic inspection whatsoever of the farms, stables, or herds from which public milk supplies come. After its arrival in the city, inspectors protect us more or less effectively from its adulteration with water. The dwellers in cities take such milk as comes, asking no questions. They have surrendered their primitive safeguards, and have placed

none in their stead. By the present system of inspection we are protected from fraud, but not from filth or disease. Public milk supplies may not legally be watered, but they may be stale or polluted or infected."

The foregoing extract deserves thoughtful consideration, in consequence of its direct bearing upon public health as affected by the milk supply. It shows very conclusively the reasons for the liability incurred by milk consumers, especially in cities, to attacks of infectious diseases Localized epidemics of typhoid fever, as well as other diseases, limited to the patrons of some particular dairy, are by no means of rare occurrence, as has been shown in previous reports of this Board. The present milk-inspection laws have little effect in preventing such outbreaks. Such was not their original intention. The law of 1889, to prevent the feeding of garbage and offal to milch cows, has a very limited application, since it must be shown in every complaint entered under this act that the person collecting such garbage acts under authority of a city or town, either by contract or otherwise.

At present the greatest difficulty in controlling the sanitary condition of dairy farms lies in the fact that the parties having the greatest interest in them, that is to say, the milk consumers, have no authority over them; since the consumers live mainly in the cities and large towns, often at a distance of twenty-five, fifty and occasionally even a hundred miles from the source of supply. Probably the greater portion of the milk consumed in Massachusetts is produced in a different county from that in which the consumers live, and a considerable portion in a different State. Hence jurisdiction cannot be assumed over dairy farms by the majority of the persons having the greatest interest in them. In England considerable progress has been made by the enactment of a "dairy and cow shed" act, which has been already quoted in the report of this Board for 1886. The Board of Health of Boston has already published a regulation having the same commendable object in view. This regulation, however, applies only to those few cows and the places in which they are kept which lie within the city limits, while the far greater number are beyond the control of the local board of health. Some other and more

general legislation seems necessary, therefore, before decided improvement can be expected throughout the milk-producing districts of the State in the sanitary condition of dairy farms.

Improvement has taken place in the character of many of the articles of food sold within the State since the beginning of the enforcement of the present food acts. The following may be cited as an example. In the report of the Board for the year 1884 comment was made upon an inquiry relative to the quality of vinegar as offered for sale in the State. The result of this inquiry was a reduction in the standard required, from 5 per cent. of acetic acid (for cider vinegar) to 4.50 per cent. Out of 273 samples obtained at that time, 107, or 39 per cent. of the whole, had more than 4.50 per cent. of acetic acid, the balance, or 61 per cent., being deficient, and therefore amenable to the action of the statutes.

In contrast to the foregoing, the following were all of the samples taken in two months recently, mostly in Boston and in neighboring cities and towns. These were mainly from groceries: —

Samples of Vinegar collected in May and June in Boston and Other Cities.

Sample Number.	Total Solids.	Per Cent. of Acetic Acid.	Sample Number.	Total Solids.	Per Cent. of Acetic Acid.
5883	3.24	5.57	7003	1.35	4.75
5895	.94	4.82	7011	3.37	5.85
5899	3.57	4.90	8402	2.50	4.52
5901	2.15	5.45	8404	2.52	4.46
5907	2.70	5.80	8574	2.69	4.56
5913	2.27	4.75	8938	2.70	5.30
5923	2.10	4.80	8940	1.40	4.30
5933	1.88	5.26	9240	3.51	4.40
6209	2.20	5.55	9254	1.98	5.50
6235	2.67	4.97	12708	5.13	4.35
6237	1.59	5.55	12712	1.85	5.75
6483	.25	4.36	12719	1.70	5.23
6487	2.09	4.57	12722	2.95	5.65
6515	2.67	4.62	12852	1.73	5.06
6717	2.47	5.88	12858	3.13	5.14
6719	.17	4.92	12861	3.83	5.00
6721	2.00	4.85	12864	2.17	4.72
6723	2.18	4.75	12992	3.50	5.12
6727	3.00	4.85	12996	3.07	5.04
6729	.43	4.69	Average, 41 samples,	2.36	5.01
6731	2.20	4.85			
6733	2.99	4.96			

Of these samples, 41 in number, five only, or 12 per cent., had less than the required ratio of acetic acid, and even these 5 were very near the standard of requirement. The average percentage of the 41 samples in acetic acid was 5.01, while that of the collection made in 1884 was only 4.27. The range of the collection of 41 recently made was but slight, the highest having 5.85 per cent. and the lowest 4.30 per cent. of acetic acid. The average solids of the 41 samples was 2.36.

CONFECTIONERY.

Within the past few years the introduction of glucose as an ingredient of different food products has greatly reduced the price of the cheaper sorts of confectionery, and has resulted in its increased consumption. Many samples have been obtained as offered for sale in different parts of the States, and have been submitted to analysis from time to time, but very rarely has any injurious ingredient been found. In one instance an itinerant confectioner, selling from a cart or street stand, was found selling confectionery of a bright yellow color, which he stated that he had made himself. A sample of this upon examination was found to be colored with chromate of lead, a poisonous color; and, complaint being made against him, he was found guilty under the general food act.

Other cases occasionally occur in which illness is attributed to some special article of food, which upon examination proves to be harmless. A case of this sort which occurred in Chelsea was investigated by the Board, in which two children, aged seven and five years, after a very hearty breakfast, purchased a small quantity of confectionery and ate it. Both children were soon taken ill with vomiting, which lasted about four hours, after which they had no further trouble. The confectionery upon examination was found to consist of sugar, flavored with liquorice and anise, without any injurious ingredient. It appeared probable, therefore, that the illness was not due to the confectionery, but to the indigestible breakfast which the children had previously eaten.

Glucose continues to play a conspicuous part as an adulterant in many articles of food, especially in the different sorts of syrups and honey. There are several small establishments in Boston and its immediate vicinity where the manufacture of

spurious syrups and honey is conducted, and the labels on these preparations, especially upon packages purporting to contain maple syrup, are usually marked "Pure." The proprietors of several of these establishments have paid repeated fines as the penalty of violating the food and drug acts, but find it sufficiently profitable to continue their fraudulent business, notwithstanding the action of justice.

The following list embraces the samples of food examined, so far as they are specified in the returns. The numbers of genuine and of adulterated samples are given for each article. No conclusions can be made from these figures, relative to the actual state of the markets, with reference to the question of adulteration in the case of any given article, since in many instances the samples were collected in consequence of a special line of investigation. For example, nearly all of the canned vegetables referred to in this table were samples of French importations suspected to contain sulphate of copper (blue vitriol) as a coloring material. Again, in the case of butter, the inspectors have become, by years of experience, familiar with the conditions and circumstances under which its substitute, oleomargarine, is fraudulently sold, and hence they select such cases for examination.

	Total.	Genuine.	Adulterated.	Ratio of Adulteration. Per Cent.
Spices,	842	696	146	17.3
Cream of tartar,	397	331	66	16.6
Butter and oleomargarine,	199	103	96	48.0
Coffee,	144	79	65	45.1
Molasses,	140	126	14	10.
Canned vegetables,	124	17	107	86.3
Tea,	67	67	0	0
Lard,	52	31	21	40.
Vinegar,	48	32	16	33.3
Honey,	47	35	12	25.5
Maple syrup,	44	26	18	41.
Olive oil,	28	12	16	57.1
Confectionery,	26	24	2	7.7
Cheese,	18	18	0	0
Maple sugar,	13	8	5	38.5
Cocoa,	5	5	0	0
Syrup,	2	1	1	50.—
Other articles of food,	89	75	14	15.7
Total,	2,285	1,686	599	26.2

The following list comprises the cities and towns in the State to which notices were sent in 1891 on account of sale of adulterated milk:—

Cities and Towns to which Notices were sent on Account of Adulterated Milk.

Bedford,	4	New Bedford,	1
Bellingham,	1	Newton,	6
Beverly,	5	North Adams,	3
Boston,	11	Northborough,	1
Brockton,	8	Plymouth,	1
Cambridge,	28	Provincetown,	2
Chelsea,	9	Quincy,	2
Chicopee,	1	Randolph,	1
Cottage City,	3	Revere,	7
Fall River,	17	Salem,	7
Falmouth,	1	Somerville,	3
Fitchburg,	5	South Framingham,	3
Gloucester,	20	Springfield,	4
Haverhill,	4	Sudbury,	1
Holliston,	2	Taunton,	2
Holyoke,	4	Waltham,	8
Hyde Park,	2	Wareham,	1
Lancaster,	2	Warren,	1
Lawrence,	4	Westfield,	2
Lowell,	6	West Medway,	7
Lynn,	20	Winthrop,	1
Malden,	6	Woburn,	1
Marlborough,	4	Worcester,	1
Medway,	1		
Nantucket,	2	Total,	238
Natick,	2		

The following is a list of the cities and towns to which notices were sent during the year on account of adulterated articles of food. The figures refer to the numbers of such notices sent to each city and town. This list does not include adulterated samples of milk:—

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food.

Adams,	2	New Bedford,	17
Amherst,	3	Newton,	4
Boston,	42	North Adams,	2
Brockton,	1	Northampton,	2
Brookline,	2	Palmer,	1
Cambridge,	3	Pittsfield,	5
Chicopee,	7	Salem,	8
Edgartown,	1	Springfield,	13
Fall River,	22	Stoneham,	1
Fitchburg,	1	Taunton,	4
Holyoke,	22	Waltham,	2
Hyde Park,	1	Ware,	1
Lawrence,	3	Westfield,	3
Lowell,	10	Woburn,	3
Lynn,	2	Worcester,	5
Marblehead,	1		
Marlborough,	2	Total,	201
Montague,	5		

As a stimulus to the production and sale of milk of good quality for the benefit of consumers in cities and towns, copies of the following circular have occasionally been issued by the Board and published in the local papers in places where inspections have been made by the officers of the Board. Evidence has in some instances been received that this practice has been attended with an improved quality of milk : —

COMMONWEALTH OF MASSACHUSETTS.

STATE BOARD OF HEALTH,
13 BEACON STREET, BOSTON, ________ 189 .

This report is issued for the benefit of cities and towns.

Report of the condition of milk-supply as found in the ________ of ________ and ascertained by analysis of samples collected ________ 189 , as delivered to the consumers from milk-wagons and from shops where milk is sold.

The legal standard of milk in Massachusetts is 13 per cent. of solid residue, except in the months of May and June, when it is 12 per cent.

INSPECTOR'S NUMBER.	TOTAL SOLIDS.	WAGON OR SHOP.

The following list of cities presents in detail the results of examination of milk obtained in the different cities of eastern Massachusetts. Those of the four western counties are presented on a later page.

Boston.

Number of samples received,	303
above standard,	172
below standard,	131
Skimmed,	4
Lowest sample (total solids),	9.78
Percentage below standard,	43.23

Worcester.

Number of samples received,	60
above standard,	47
below standard,	13
Skimmed,	2
Lowest,	10.42
Percentage below standard,	21.67

Lowell.

Number of samples received,	107
above standard,	76
below standard,	31
Skimmed,	2
Lowest,	9.41
Percentage below standard,	28.97

Fall River.

Number of samples received,	109
above standard,	50
below standard,	59
Lowest,	8.70
Percentage below standard,	54.13

Cambridge.

Number of samples received,	185
above standard,	84
below standard,	101
Skimmed,	1
Lowest,	8.08
Percentage below standard,	54.59

Lynn.

Number of samples received,	89
above standard,	32
below standard,	57
Skimmed,	1
Lowest,	10.62
Percentage below standard,	64.04

Lawrence.

Number of samples received,	71
above standard,	51
below standard,	20
Skimmed,	5
Lowest,	10.22
Percentage below standard,	28.16

New Bedford.

Number of samples received,	16
above standard,	14
below standard,	2
Lowest,	11.72
Percentage below standard,	12.50

Somerville.

Number of samples received,	41
above standard,	21
below standard,	20
Lowest,	11.68
Percentage below standard,	48.78

Salem.

Number of samples received,	84
above standard,	55
below standard,	29
Lowest,	8.71
Percentage below standard,	34.52

Chelsea.

Number of samples received,	46
above standard,	18
below standard,	28
Lowest,	9.43
Percentage below standard,	60.87

Haverhill.

Number of samples received,	52
above standard,	28
below standard,	24
Lowest,	10.53
Percentage below standard,	46.15

Brockton.

Number of samples received,	36
above standard,	17
below standard,	19
Lowest,	10.61
Percentage below standard,	52.78

Taunton.

Number of samples received,	48
above standard,	33
below standard,	15
Skimmed,	1
Lowest,	10.54
Percentage below standard,	31.25

Newton.

Number of samples received,	74
above standard,	42
below standard,	32
Skimmed,	1
Lowest,	11.10
Percentage below standard,	43.24

Malden.

Number of samples received,	22
above standard,	6
below standard,	16
Lowest,	9.90
Percentage below standard,	72.72

Fitchburg.

Number of samples received,	37
above standard,	19
below standard,	18
Lowest,	10.99
Percentage below standard,	48.65

Gloucester.

Number of samples received,	49
above standard,	23
below standard,	26
Lowest,	9.08
Percentage below standard,	53.06

Waltham.

Number of samples received,	40
above standard,	10
below standard,	30
Lowest,	9.23
Percentage below standard,	75.00

Quincy.

Number of samples received,	36
above standard,	26
below standard,	10
Skimmed,	1
Lowest,	11.50
Percentage below standard,	27.77

Newburyport.

Number of samples received,	15
above standard,	15
below standard,	0
Lowest,	12.59
Percentage below standard,	0

Marlborough.

Number of samples received,	50
above standard,	32
below standard,	18
Skimmed,	1
Lowest,	9.81
Percentage below standard,	36.00

Woburn.

Number of samples received,	10
above standard,	1
below standard,	9
Lowest,	11.46
Percentage below standard,	90.00

The following is a summary of the foregoing statistics relative to the milk obtained in the cities of the eastern portion of the State: —

	Total.	Above Standard.	Below Standard.	Percentage below Standard.	Skimmed.
Boston,	303	172	131	43.23	4
Worcester,	60	47	13	21.67	2
Lowell,	107	76	31	28.97	2
Fall River,	109	50	59	54.13	-
Cambridge,	185	84	101	54.59	1
Lynn,	89	32	57	64.04	1
Lawrence,	71	51	20	28.16	5
New Bedford,	16	14	2	12.50	-
Somerville,	41	21	20	48.78	-
Salem,	84	55	29	34.52	-
Chelsea,	46	18	28	60.87	-
Haverhill,	52	28	24	46.15	-
Brockton,	36	17	19	52.78	-
Taunton,	48	33	15	31.25	1
Newton,	74	42	32	43.24	1
Malden,	22	6	16	72.72	-
Fitchburg,	37	19	18	48.65	-
Gloucester,	49	23	26	53.06	-
Waltham,	40	10	30	75.00	-
Quincy,	36	26	10	27.77	1
Newburyport,	15	15	0	00.00	-
Marlborough,	50	32	18	36.00	1
Woburn,	10	1	9	90.00	-
	1,580	872	708	44.81	19

Taunton.

Number of samples received,	48
above standard,	33
below standard,	15
Skimmed,	1
Lowest,	10.54
Percentage below standard,	31.25

Newton.

Number of samples received,	74
above standard,	42
below standard,	32
Skimmed,	1
Lowest,	11.10
Percentage below standard,	43.24

Malden.

Number of samples received,	22
above standard,	6
below standard,	16
Lowest,	9.90
Percentage below standard,	72.72

Fitchburg.

Number of samples received,	37
above standard,	19
below standard,	18
Lowest,	10.99
Percentage below standard,	48.65

Gloucester.

Number of samples received,	49
above standard,	23
below standard,	26
Lowest,	9.08
Percentage below standard,	53.06

Waltham.

Number of samples received,	40
above standard,	10
below standard,	30
Lowest,	9.23
Percentage below standard,	75.00

Quincy.

Number of samples received,	36
above standard,	26
below standard,	10
Skimmed,	1
Lowest,	11.50
Percentage below standard,	27.77

Newburyport.

Number of samples received,	15
above standard,	15
below standard,	0
Lowest,	12.59
Percentage below standard,	0

Marlborough.

Number of samples received,	50
above standard,	32
below standard,	18
Skimmed,	1
Lowest,	9.81
Percentage below standard,	36.00

Woburn.

Number of samples received,	10
above standard,	1
below standard,	9
Lowest,	11.46
Percentage below standard,	90.00

The following is a summary of the foregoing statistics relative to the milk obtained in the cities of the eastern portion of the State: —

	Total.	Above Standard.	Below Standard.	Percentage below Standard.	Skimmed.
Boston,	303	172	131	43.23	4
Worcester,	60	47	13	21.67	2
Lowell,	107	76	31	28.97	2
Fall River,	109	50	59	54.13	-
Cambridge,	185	84	101	54.59	1
Lynn,	89	32	57	64.04	1
Lawrence,	71	51	20	28.16	5
New Bedford,	16	14	2	12.50	-
Somerville,	41	21	20	48.78	-
Salem,	84	55	29	34.52	-
Chelsea,	46	18	28	60.87	-
Haverhill,	52	28	24	46.15	-
Brockton,	36	17	19	52.78	-
Taunton,	48	33	15	31.25	1
Newton,	74	42	32	43.24	1
Malden,	22	6	16	72.72	-
Fitchburg,	37	19	18	48.65	-
Gloucester,	49	23	26	53.06	-
Waltham,	40	10	30	75.00	-
Quincy,	36	26	10	27.77	1
Newburyport,	15	15	0	00.00	-
Marlborough,	50	32	18	36.00	1
Woburn,	10	1	9	90.00	-
	1,580	872	708	44.81	19

DRUGS.

Since the act of 1882, relative to food and drug inspection, requires that three-fifths of the appropriation for its enforcement shall be expended upon the inspection of milk and milk products, it is plain that the work of drug inspection must be of a limited character. Notwithstanding this fact, the number of samples examined in 1891 was 424, of which number 352, or 83 per cent., were found to conform to the requirements of the statutes. These included specimens of 43 different pharmacopœial preparations which were selected for examination mainly on account of special liability to adulteration. Hence the ratio of adulteration found upon examination (17 per cent.), small as it is, is undoubtedly considerably in excess of the actual ratio of general drug adulteration in the State.

Among the number of samples of drugs are included 34 samples of empirical preparations, the greater number of which were cosmetics of a more or less poisonous and decidedly harmful character. Some of these were described in the last annual report, and others have been made the subject of complaint at court during the past year.

It occasionally happens that pharmacopœial preparations vary considerably from the required standard in the case of articles where such variation would be least expected. For example, an article so simple and easily obtained as *distilled water* presented the following ranges of variation in the amount of solid matter contained in 7 samples obtained in different cities in the State: —

	Total solids, parts per 100,000.
Sample No. 1, Boston,	2.2
Sample No. 2, Boston,	12.2
Sample No. 3, Boston,	20.6
Sample No. 4, New Bedford,	0.0
Sample No. 5, Fall River,	4.0
Sample No. 6, Haverhill,	17.8
Sample No. 7, Gloucester,	32.0

An examination of the foregoing list shows a range in the amount of total solids in the samples offered as distilled water varying from 0 to 32 parts in 100,000. It also shows the possibility of procuring an absolutely pure distilled water.

There is no excuse, however, for furnishing to a customer a sample of water of a quality nearly as bad as the average sewage of a city, as in the sample No. 7 of the foregoing list.

A considerable change has constantly been going on in the character of the drugs employed for the treatment of disease, especially during the past ten or twenty years, and very many synthetic drugs, the products of the chemist's laboratory, have supplanted to a considerable degree the materia medica of older times. Some of these which have proved to be of undoubted value have been admitted to the U. S. Pharmacopœia after the test of experience had been applied to them. The number of such preparations which has come into existence within the past decade has been unusually large, much greater than those which had appeared previous to the publication of the Pharmacopœia of 1880.

The Board has not confined its inspection of drugs to those which are officinal only, since the law of 1882 applies not only to the drugs of the U. S. Pharmacopœia but also to those of other pharmacopœias and standard works on materia medica, and, in fact, to all medicines sold for external or internal use, and to disinfectants, antiseptics and cosmetics. Hence occasional examinations have been made of empirical preparations, and especially of such as are of an injurious or fraudulent character. As examples, may be mentioned an examination of hair dyes and of so-called opium cures in 1885, of tonics and bitters in 1887.

Prosecutions.

The prosecutions which were conducted during the year will be found detailed in the following summary, a copy of which was submitted to the Legislature early in the present year, in compliance with the provisions of the food and drug acts. The following comment upon this summary should be noted. The number of prosecutions for violation of the laws relative to the sale of oleomargarine was very much smaller than that of the previous year, a fact which was not due to lessened vigilance on the part of the inspectors, but to the effect of an unusually rigid enforcement of the laws in 1890, so that cases of violation of the statutes had become of rare occurrence. A new act was passed in 1891, giving added power to local milk

inspectors relative to the sale of oleomargarine; and still another act in the same year, establishing a dairy bureau, to which power was given for the same purpose; so that butter in Massachusetts has now the protection afforded by four different sets of officials, — namely, the internal revenue officers, the State Board of Health, the local milk inspectors, and the Dairy Bureau.

OFFICE OF THE STATE BOARD OF HEALTH,
13 BEACON STREET, BOSTON, March, 1892.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts, in General Court assembled.

The following summary is made in compliance with the provisions of chapter 289, section 2, of the Acts of 1884, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions made under chapter 263 of the Acts of 1882, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1891, was 150.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials and their result, are presented in the following table: —

MILK AND MILK PRODUCTS.

For Fraudulent Sales of Milk.

PLACE.	DATE.	RESULT.
In Salem,	Nov. 21, 1890,	Convicted.
Salem,	May 8, 1891,	"
Salem,	May 15, 1891,	"
Lowell,	Nov. 26, 1890,	"
Lowell,	Mar. 16, 1891,	Discharged.
Gloucester,	Dec. 12, 1890,	Convicted.
Gloucester,	May 23, 1891,	"
Gloucester,	May 23, 1891,	"
Gloucester,	July 24, 1891,	"
Gloucester,	July 24, 1891,	"
Quincy,	April 18, 1891,	"
Fall River,	April 21, 1891,	"
Fall River,	April 24, 1891,	"

For Fraudulent Sales of Milk — Concluded.

Place.	Date.	Result.
In Fall River,	May 13, 1891,	Convicted.
Fall River,	May 13, 1891,	"
Fall River,	Aug. 20, 1891,	Discharged.
Northampton,	June 2, 1891,	Convicted.
Lynn,	Sept. 17, 1891,	"
Lynn,	Sept. 17, 1891,	"
Lynn,	Sept. 17, 1891,	"
Taunton,	Sept. 15, 1891,	"
North Adams,	Jan. 28, 1891,	"
North Adams,	July 31, 1891,	Discharged.
North Adams,	July 31, 1891,	"
North Adams,	Aug. 12, 1891,	Convicted.
Revere,	Sept. 4, 1891,	Discharged.
Revere,	Sept. 12, 1891,	"
Revere,	Sept. 12, 1891,	"
Winthrop,	Aug. 14, 1891,	"
Grafton,	Oct. 1, 1890,	Convicted.
Lexington,	Oct. 18, 1890,	"
Warren,	Oct. 25, 1890,	"
Holliston,	Oct. 18, 1890,	"
Edgartown,	Oct. 31, 1890,	Discharged.
Sudbury,	Nov. 15, 1890,	Convicted.
Sudbury,	Jan. 24, 1891,	"
Weston,	Nov. 15, 1890,	"
Wayland,	July 26, 1891,	"
Wayland,	Aug. 13, 1891,	"
Boxborough,	April 11, 1891,	Discharged.
Braintree,	April 15, 1891,	Convicted.
Carlisle,	April 4, 1891,	"
Agawam,	Dec. 18, 1890,	"
North Easton,	Sept. 12, 1891,	"
Harvard,	Aug. 6, 1891,	"
Peabody,	Sept 17, 1891,	"
Peabody,	Sept. 17, 1891,	"
Somerset,	Sept. 25, 1891,	Discharged.
Westport,	Sept. 25, 1891,	"
	Total 49 cases.	

For Fraudulent Sales of Butter. (*Oleomargarine*)

In Marlborough,	Oct. 17, 1890,	Convicted.
Lawrence,	Oct. 20, 1890,	"
Lynn,	Dec. 20, 1890,	"
	Total 3 cases.	

Other Articles of Food.

Molasses.

Place.	Date.	Result.
In Salem,*	Aug. 11, 1890,	Convicted.
North Adams,	Nov. 6, 1890,	"
North Adams,	Nov. 6, 1890,	"
Springfield,	Dec. 13, 1890,	"
Pittsfield,	Aug. 20, 1891,	"

Coffee.

In Boston,	Oct. 31, 1890,	Convicted.
Boston,	Oct. 31, 1890,	"
Boston,	Nov. 15, 1890,	"
Boston,	April 4, 1891,	"
Boston,	May 14, 1891,	"
Lowell,	Dec. 16, 1890,	"
Lowell,	Jan. 13, 1891,	"
Fall River,	April 15, 1891,	"
Fall River,	April 24, 1891,	"
Fall River,	May 1, 1891,	"
Springfield,	April 29, 1891,	"
Springfield,	May 1, 1891,	"
Springfield,	May 1, 1891,	"
Springfield,	May 1, 1891,	"
Springfield,	May 4, 1891,	"
New Bedford,	May 8, 1891,	"
Salem,	June 9, 1891,	"
North Adams,	Aug. 7, 1891,	"
North Adams,	Sept. 26. 1891,	"
Huntington,	Aug. 27, 1891,	"
Huntington,	Aug. 27, 1891,	"
Huntington,	Aug. 27, 1891,	"
Chester,	Aug. 28, 1891,	"
Chester,	Aug. 28, 1891,	"
Westfield,	Sept. 4, 1891,	"
Adams,	Sept. 17, 1891,	"
Adams,	Sept. 30, 1891,	"
Pittsfield,	Sept. 18, 1891,	"

Pepper.

In Haverhill,	Oct. 23, 1890,	Convicted.
Lowell,	Dec. 19, 1890,	"
Boston,	May 26, 1891,	"
Boston,	Aug. 27, 1891,	"
Chicopee,	May 25, 1891,	†

* This case was omitted from the report of the previous year.

† Left the State before case was called in court.

Pepper — Concluded.

Place.	Date.	Result.
In New Bedford,	May 8, 1891,	Convicted.
Salem,	June 9, 1891,	"
Salem,	July 18, 1891,	"
North Adams,	Nov. 6, 1890,	"
Adams,	Nov. 21, 1890,	"
Adams,	Jan. 9, 1891,	"
Adams,	Sept. 17, 1891,	"
Fall River,	June 8, 1891,	"
Huntington,	Aug. 27, 1891,	"
Westfield,	Sept. 4, 1891,	"
Turner's Falls (Montague),	Sept. 26, 1891,	"

Maple Syrup.

In Boston,	April 25, 1891,	Convicted.
Holyoke,	Mar. 31, 1891,	"
Springfield,	May 27, 1891,	"
Fall River,	Dec. 20, 1890,	"
Fall River,	June 9, 1891,	"
Fall River,	June 9, 1891,	"

Vinegar.

In North Adams,	Nov. 6, 1890,	Convicted.
North Adams,	Nov. 6, 1890,	"

Cream of Tartar.

In Marlborough,	Oct. 10, 1890,	Convicted.
Marlborough,	Oct. 10, 1890,	"
Lowell,	Dec. 18, 1890,	"
Lynn,	Dec. 20, 1890,	"
Boston,	Feb. 2, 1891,	"
Boston,	Aug. 27, 1891,	"
Fitchburg,	April 20, 1891,	"
Fall River,	April 24, 1891,	"
Fall River,	June 9, 1891,	"
North Adams,	Nov. 6, 1890,	"
North Adams,	Nov. 6, 1890,	"
North Adams,	Nov. 6, 1890,	"
North Adams,	Nov. 6, 1890,	"
North Adams,	Nov. 6, 1890,	"
Adams,	Nov. 21, 1890,	"
Adams,	Jan. 14, 1891,	"
Adams,	Jan. 14, 1891,	"
Chicopee,	May 25, 1891,	*

* Left the State before the case was called in court.

Cream of Tartar — Concluded.

Place.	Date.	Result.
In Huntington,	Aug. 27, 1891,	Convicted.
Holyoke,	April 17, 1891,	"
Holyoke,	April 17, 1891,	"
Holyoke,	April 17, 1891,	"
Holyoke,	May 14, 1891,	"
Holyoke,	May 14, 1891,	"
Holyoke,	May 14, 1891,	"
Holyoke,	May 21, 1891,	"

Lard.

In North Adams,	Nov. 6, 1890,	Convicted.
North Adams,	Nov. 6, 1890,	"

Maple Sugar.

In Boston,	April 9, 1891,	Convicted.

Honey.

In Chicopee,	June 18, 1891,	Convicted.
Pittsfield,	Aug. 20, 1891,	"
Boston,	Aug. 27, 1891,	"

Mustard.

In New Bedford,	May 8, 1891,	Convicted.
Westfield,	Sept. 4, 1891,	"

Cloves.

In Lawrence,	Sept. 23, 1891,	Convicted.

Canned Peas (French).

In Boston,	Aug. 3, 1891,	Convicted.

DRUGS AND COSMETICS.

Place.	Date.	Result.
In Boston,	Nov. 14, 1890,	Convicted.
Boston,	Nov. 14, 1890,	"
Lynn,	Dec. 20, 1890,	Discharged.
Lowell,	Jan. 6, 1890,	Convicted.
Lowell,	Jan. 6, 1890,	"

Milk and milk products,	52 cases.
Other articles of food,	93 "
Drugs and cosmetics,	5 "
Total,	150 "

SUMMARY.

The whole number of complaints entered by the State Board of Health in the courts of the Commonwealth against parties for violation of the acts relating to the adulteration of food and drugs was 150, of which number 135, or 90 per cent., were convicted. Thirteen were discharged, either in the lower or the upper courts, and 2 left the State before the cases came to trial.

Of the foregoing cases, 49 were for violation of the laws relating to milk adulteration, of which number 37 resulted in conviction. There were 3 cases under the oleomargarine laws, all of which resulted in conviction. There were also 93 complaints for fraudulent sales of other kinds of food, in all of which except two the parties were convicted, the two exceptions being in the cases of two parties who had left the State before the cases could come to trial.

The articles of food other than milk embraced in the foregoing list were as follows: —

Molasses, 5 cases; coffee, 28; pepper, 16; maple syrup, 6; maple sugar, 1; cream of tartar, 26; vinegar, 2; lard, 1; honey, 3; mustard, 2; cloves, 1; French peas, 1.

In a large number of cases appeals were made by the defendants, but in nearly all of these the defendants paid the fines which had been imposed, before the cases were called for trial.

In one case only out of all which have been decided in the superior courts, the decision of the lower court was reversed by the upper court.

The total solids in the samples of milk upon which complaints were founded were as follows, in the case of those complaints in which the records were noted: —

9.14	9.90	10.02	10.05	10.10	10.22
10.22	10.50	10.61	10.75	10.76	10.80
10.83	10.83	10.86	10.88	11.07	11.14
11.18	11.18	11.18	11.26	11.41	11.41
11.50	11.50	11.53	11.60	11.62	11.66
11.76	11.80	11.81	11.82	11.85	11.94

FINES.

The amount of the fines paid to the treasuries of counties, cities and towns, under the provisions of the general and special laws relative to the inspection of food and drugs, was as follows: —

Fines paid for Violation of the Food and Drug Acts, upon Cases entered for the Year ending Sept. 30, 1891.

Under the provisions of the laws relating to milk and milk products,	$1,271 00
Under the provisions of laws relative to other articles of food,	1,337 35
Under the provisions of laws relative to drugs,	60 00
Total,	$2,668 35

EXPENDITURES

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1891.

	For Enforcing the Statutes.	
	Relative to Milk and Milk Products.	Relative to Other Kinds of Food and Drugs.
Salaries of analysts,	$2,820 00	$1,880 00
Salaries of inspectors,	1,860 00	1,240 00
Travelling expenses and purchase of samples,	1,250 00	825 00
Legal services,	100 00	18 40
Incidentals, bottles, corks, etc.,	10 50	6 22
Printing,	9 29	-
	$6,049 79	$3,969 62
		6,049 79
Total,	. . .	$10,019 41

SAM'L W. ABBOTT,
Secretary.

REPORTS OF THE ANALYSTS.

REPORTS OF THE ANALYSTS.

DR. HARRINGTON'S REPORT UPON FOOD.

BOSTON, Oct. 1, 1891.

Dr. S. W. ABBOTT, *Secretary State Board of Health.*

DEAR SIR: — During the year ending Sept. 30, 1891, I have received and examined as analyst of foods 1,286 samples, including 247 which proved to be adulterated. Referring to the record books of the inspectors for the purpose of obtaining the brands of the adulterated samples for this report, I have been struck with the fact that most of the old familiar markings which have been published in previous reports have about disappeared from the market, for nearly all of the adulterated samples among the spices, condiments, cream of tartar, etc., have been sold either in bulk or in packages marked "Select," "Premium," "Best," etc., but without the name of the compounder.

The percentage of adulterated samples is low, and more than a fifth of these are articles the character of which was known at the time of the sale, but which have not before been extensively examined, — French canned vegetables greened by treatment with sulphate of copper.

Forty-six cans of pease and four of string-beans were found to contain copper, and one of pease and three of beans to be free from it. The amount of copper per can averages about two grains, reckoned as sulphate. The addition of this substance is clearly an adulteration, as the copper serves no useful purpose, and may produce harm.

Another undesirable addition to foods is salicylic acid, which is used as a preservative. This was detected in two samples of California apricot juice, in raspberry, lemon, vanilla and strawberry syrups put up by a Boston manufacturer, and in imported lager beer. Other adulterants detected were of the usual harmless varieties.

Following are the samples examined:—

Butter.—Twenty-seven samples, with one exception genuine.

Cheese.—Eleven samples, all genuine.

Lard.—Sixteen samples. Five of these were mixtures with stearine and cotton-seed oil, the remainder were genuine.

Molasses.—Ninety-one samples, of which but six were adulterated with glucose. No tin was detected.

Maple Syrup and *Maple Sugar.*—Thirty-nine samples. Eighteen were spurious.

Honey.—Twenty samples. One consisted largely of glucose syrup.

Sugar.—Nine samples, three of powdered, two of granulated and four of brown. All genuine.

Confectionery.—Of thirty-one samples examined only two could be said to contain any objectionable ingredient. These contained alcohol in the form of brandy or whisky in sufficient amount to affect the system, even when eaten in moderation.

Vinegar.—Sixteen samples, of which five contained less than the required amount of acidity.

Cider Vinegar.—Nineteen samples. Two were deficient in acidity and two in cider-vinegar solids.

Cream of Tartar.—Two hundred and fourteen samples. Of the twenty-four samples which proved to be adulterated, only five were in marked packages. These were labelled as follows: Finest Quality for Family Use (two); Blanchard's Best; Challenge Mill XXX; XXX First Quality. The amount of foreign matter in the samples bearing the first, second and fourth of these markings was more than seventy-five per cent.

Baking Powders.—Fifteen samples. Five proved to be cream of tartar powders, one was chiefly coarse hominy, and

nine contained alum as the acid salt. The following are the names of the ten which may be considered as adulterated, the first-mentioned being the one consisting of hominy, the others containing alum: Home Circle; Cottage; Red Star; Bon Bon; Grape Crystal; Cottage; Kitchen Queen; Household; Crystal; Western Pearl.

Saleratus. — Six samples, all genuine.

Canned Vegetables. — Fifty-four samples. Fifty contained copper.

Mustard. — Fifty-nine samples. Nineteen contained wheat flour or rice. Three of these were labelled, but not with the makers' names: No. 1474, Gilt Edge; No. 1724, Durham; No. 8313, London.

Cayenne. — Thirty-nine samples. Three contained wheat flour; three were largely corn meal; one contained twenty per cent. of rice, wheat and other foreign matter, and one was a mixture of various substances with a very slight amount of cayenne.

Mace. — Eight samples. One contained a fourth part of wheat.

White Pepper. — Thirty-four samples. Six unlabelled packages were adulterated with rice, corn or wheat.

Black Pepper. — One hundred and fifty-seven samples. Twenty contained ground cracker, two contained rice, four corn, four cracker and corn, one oat meal and buckwheat, and one was Malaguetta pepper. Only one of the thirty-two adulterated samples was labelled with the name of the manufacturers: No. 9101, D. E. Rounds & Co., Providence.

Cassia. — One hundred and three samples. Fourteen were adulterated. The following were among the latter: No. 1932, Union Spice Company; No. 2826, Parsons' Premium, Albany; No. 3862, W. H. Gilbert & Co.; No. 9237, Select; No. 8831, Ar Showe & Co.; No. 1377, Globe.

Cloves. — One hundred and eighteen samples. Fifteen contained the usual admixtures. Only two bore brands: No. 2824, Parsons' Premium, Albany; No. 9287, Select.

Allspice. — Forty-seven samples. Four were adulterated, including No. 9099, D. E. Rounds & Co., Providence.

Ginger. — Fifty-one samples. Four were adulterated, including No. 1934, Union Spice Co., N. Y.; No. 9103, D. E. Rounds & Co., Providence.

Coffee. — Thirty-eight samples. Seven consisted wholly of burnt pease and rye with chicory.

Tea. — Twenty-nine samples; *Chocolate*, four samples, and *Cocoa*, three samples. All genuine.

Olive Oil. — Six samples. Three consisted of cotton-seed oil: No. 677, E. Loubon, Nice; No. 1431, C. H. Carton, Nice; No. 2129, B. Dufour & Cie, Bordeaux.

Miscellaneous. — The following articles were examined for salicylic acid, and were found to contain it: California Apricot Juice, non-alcoholic, E. L. Watkins, San Gabriel, Cal. (two samples); Kaiser Beer, Bremen, F. Hollender & Co., Sole Agents; Pure Fruit Syrup, Strawberry, F. P. Adams & Co., Boston; Pure Fruit Syrup, Raspberry (two), F. P. Adams & Co., Boston; Lemon Syrup (Adams); Vanilla Syrup (Adams).

The following were examined for salicylic acid, with negative results: strawberry jam; lemon syrup; grape juice; "blood orange" (two samples); "sarsaparilla;" lager beer ("Pavonia"); orange syrup.

The following contained no foreign substances: gelatine (three samples), pickles, celery salt, nutmeg (one each).

Total, 1,286 samples: 1,039 genuine and 247 adulterated.

Respectfully,

CHARLES HARRINGTON, M.D.

DR. WORCESTER'S REPORT UPON MILK.

Dr. S. W. ABBOTT, *Secretary of the State Board of Health.*

DEAR SIR: — I have the honor to submit the following report on the analysis of milk for the year ending September 30.

The 1,535* samples received during the year were taken from dealers in eighteen cities and eleven towns of the State, and from fifteen suspected producers. Twenty-five samples were of known purity and eight of "skim-milk." In tabular form the results of my analyses may be stated as follows: —

Percentage of standard quality of whole number received, . . . 49.2
" " " samples taken from cities, . . 50.6
" " " " " towns, . . 59.8
Percentage of standard quality of samples taken from suspected producers, ... 29.0

	From Cities.	From Towns.	From Suspected Producers.	Of Known Purity.
Number above the standard,	562	141	29	17
Number below the standard,	548	95	127	8
Total,	1,110	236	156	25
Number having more than 15 per cent. of total solids,	30	22	0	1
" " between 14 and 15 " " "	65	30	5	4
" " " 13 and 14 " " "	376	75	19	12
" " " 12 and 13 " " "	440	77	77	7
" " " 11 and 12 " " "	142	25	38	1
" " " 10 and 11 " " "	38	5	6	0
" " " 9 and 10 " " "	20	2	4	0
" " " 8 and 9 " " "	3	0	2	0
" " " 7 and 8 " " "	1	0	5	0
Number samples of "skim-milk" above standard,	6	1	0	0
" " " below "	1	0	0	0

* The actual number of samples received was somewhat greater than appears, owing to the fact that certain samples of known purity received during the early part of the year were included in my last report, in order to complete the series.

Respectfully,

CHARLES P. WORCESTER.

BOSTON, Oct. 1, 1891.

DR. DAVENPORT'S REPORT UPON FOOD.

BOSTON, Jan. 15, 1892.

To the State Board of Health.

I have the honor to present the following report of analysis of articles of food during the past year: —

Articles Examined.	Standard.	Not.	Total.	Articles Examined.	Standard.	Not.	Total.
Butter, . .	69	95	164	Cream of tartar,	126	35	161
Cheese, . .	10	–	10	Molasses, .	40	7	47
Lard, . . .	6	13	19	Syrups, . .	4	1	5
Olive oil, . .	2	9	11	Maple sugar, .	4	1	5
Vinegar, . .	4	6	10	Maple syrup, .	15	–	15
Spices: —				Canned goods:			
Salt, . .	1	–	1	Peas, . .	9	45	54
Alspice, . .	15	–	15	Beans, . .	–	3	3
Cinnamon, .	8	–	8	Honey, . .	13	8	21
Cloves, . .	12	–	12	Tea, . .	20	–	20
Ginger, . .	3	–	3	Coffee, .	46	57	103
Mace, . .	3	–	3	Chocolate, .	–	–	–
Mustard, .	38	12	50	Confectionery,	7	–	7
Pepper, . .	72	21	93	Pickles, . .	2	1	3
Jelly, . .	6	4	10	Cider, . .	1	–	1
Vanilla extract,	1	1	2				
Baking powder,	1	1	2	Totals, .	538	320	858

The only new forms of adulteration met with during the year, and which have not already been mentioned in my previous reports, have been several samples of cream of tartar wholly composed of lime sulphate, except for the small proportion of tartaric acid needed to give them the slightly acid taste of true cream of tartar; also some samples of mustard composed wholly of corn and wheat flour, colored and flavored to imitate the true powder.

BENNETT F. DAVENPORT,
Analyst.

DR. DAVENPORT'S REPORT UPON MILK.

BOSTON, Jan. 15, 1892.

To the State Board of Health.

I have the honor to present the following report of analysis of milk during the past year: —

Number above the standard,	587	
Number below the standard,	258	
Total,		845
Number having more than 15 per cent. of total solids,	30	
" " between 14 and 15 per cent. of total solids,	104	
" " " 13 and 14 " " "	358	
" " " 12 and 13 " " "	277	
" " " 11 and 12 " " "	53	
" " " 10 and 11 " " "	14	
" " " 9 and 10 " " "	8	
" " " 8 and 9 " " "	1	
Number having less than eight per cent. of total solids,	0	
Number samples of skimmed milk above the standard,	14	
Number samples of skimmed milk below the standard,	0	
Number samples of colored milk,	0	

BENNETT F. DAVENPORT,
Analyst.

DR. DAVENPORT'S REPORT UPON DRUGS.

To the State Board of Health.

I have the honor to present the following report of analysis of drugs during the past year: —

Number conforming to the standard, ...	352
Number adulterated or not conforming to the standard, .	72
Total, ...	424

Articles Examined.	Standard.	Not.	Total.	Articles Examined.	Standard.	Not.	Total.
Opium, powdered,	5	–	5	Glycerine, . .	44	–	44
Opium, tincture, .	28	4	32	Pepsin saccharated, . .	8	–	8
Opium, camphorated tincture, .	1	–	1	Bismuth salts, .	12	–	12
Quinine, . . .	15	–	15	Cosmetics, . .	10	18	28
Quinine and iron citrate, . . .	15	–	15	Musk, ...	–	1	1
Nux vomica tincture, ...	3	2	5	Confections, .	4	–	4
Ether, stronger, .	26	–	26	Magnesia sulphate, . .	3	–	3
Spirits, nitrous ether, . .	10	3	13	Solution magnesia citrate, . .	7	1	8
Spirits ether compound, . .	1	7	8	Licorice, . .	11	1	12
Ethereal oil, . .	–	1	1	Aloes, ...	6	1	7
Alcohol, . .	8	–	8	Cinnamon, . .	5	–	5
Brandy, .	–	4	4	Cloves, . . .	5	–	5
Red wine, . .	2	3	5	Ginger, . . .	8	–	8
Iodoform, . . .	7	–	7	Pepper, . . .	2	–	2
Chloroform, . .	1	–	1	Arrow root, .	2	–	2
Chloral, . . .	3	–	3	Lycopodium, .	10	1	11
Menthol, . .	3	–	3	Acid benzoic, .	8	–	8
Lemon oil, . .	5	–	5	Acid tannic, .	40	–	40
Olive oil, . .	21	19	40	Acid hydrobromic,	1	1	2
Sweet almond oil,	1	–	1	Potash, iodide, .	3	2	5
Honey, ...	3	–	3	Potash, bitartrate,	1	–	1
Jalap, ...	–	3	3	Silver nitrate, .	2	–	2
				Distilled water, .	2	–	2
				Totals, . .	352	72	424

The only unusual and not previously reported form of adulteration met with by me during the year was a sample of lycopodium composed wholly of precipitated sulphur; this, however, was most likely only an accidental substitution.

BENNETT F. DAVENPORT,
Analyst.

BOSTON, Jan. 15, 1892.

PROFESSOR GOESSMANN'S REPORT.

Milk of Western Massachusetts.

The examination of the milk obtained in the four western counties of the State as usual presents a good result as compared with that of the eastern counties.

The whole number of samples examined was 326. (The whole number collected was 346, but of this number 20 were too sour for analysis when they were received by the chemist.)

The results of analysis were as follows: —

Whole number examined,	326
Number above standard,	266
Number below standard,	60
Percentage below standard,	18.4
Samples of skimmed milk,	12

The statistics of the cities are as follows: —

Chicopee.

Number of samples,	44
Number above standard,	41
Number below standard,	3
Percentage below standard,	6.8
Skimmed milk,	2

Holyoke.

Number of samples,	65
Number above standard,	52
Number below standard,	13
Percentage below standard,	20.0
Skimmed milk,	5

Northampton.

Number of samples,	17
Number above standard,	15
Number below standard,	2
Percentage below standard,	11.8
Skimmed milk,	1

Springfield.

Number of samples,	81
Number above standard,	65
Number below standard,	16
Percentage below standard,	19.8
Skimmed milk,	3

Pittsfield.

Number of samples,	16
Number above standard,	12
Number below standard,	4
Percentage below standard,	25.0

The results in the towns were as follows: —

	Total.	Above Standard.	Below Standard.	Percentage below Standard.
Adams,	16	12	4	-
North Adams,	43	32	11	-
Montague,	16	15	1	-
Ware,	12	10	2	-
Westfield,	15	11	4	-
	102	80	22	21.6

C. A. GOESSMANN,
Analyst.

AMHERST, MASS.

REPORT UPON ARSENIC IN WALL-PAPER AND FABRICS.

DR. HILLS' REPORT UPON ARSENIC IN WALL-PAPERS AND FABRICS.

After a prolonged hearing before the committee on Public Health of the Legislature of 1891, at which much evidence was presented with reference to the dangers which may occur in connection with the use of arsenic as a pigment, for the purpose of coloring many of the articles in common household use, the following law was enacted: —

[CHAP. 374, ACTS OF 1891.]

AN ACT RELATIVE TO THE SALE OF ARTICLES CONTAINING ARSENIC.

Be it enacted, etc., as follows:

SECTION 1. Whoever by himself or by his servant or agent, or as the servant or agent of any other person, manufactures, sells or exchanges, or has in his custody or possession with intent to sell or exchange, or exposes or offers for sale or exchange, any children's toys or confectionery, containing or coated wholly or in part with arsenic, shall be punished by fine of not less than fifty nor more than one hundred dollars.

SECT. 2. The state board of health may make such investigations and inquiries as they deem necessary as to the existence of arsenic in any paper, fabric or other article offered for sale or exchange, and for that purpose may appoint inspectors and chemists, and expend an amount not exceeding one thousand dollars, and report to the next legislature in print on or before the first day of February in the year eighteen hundred and ninety-two.

SECT. 3. Every person offering or exposing for sale or exchange any paper, fabric or other article shall furnish a sample thereof sufficient for the purpose of analysis, where such sample can be obtained without damage to the remaining portion, to any inspector, chemist or other agent or officer employed by the state board of health, who shall apply to him therefor for that purpose and who shall tender him the value of the same. Whoever violates the provisions of this section shall be punished as provided in section one of this act. [*Approved June 5, 1891.*

The State Board of Health attended to the duties authorized in the foregoing act, and appointed Dr. Wm. B. Hills of the medical department of Harvard University to make the investigations referred to in the second section of the act. The following report contains the results of his inquiries.

The broader question as to the actual effect of the common use of arsenic as a pigment upon the public health appears to be excluded by the limited provisions of section 2 of this act.

These more important questions are at present the subject of further investigations, and will be reported upon by the Board at a future day.

Dr. Hills' Report.

The following investigation was undertaken in accordance with a Resolve adopted by the Legislature of 1891, whereby the State Board of Health was authorized to make such investigations and inquiries as it might deem necessary as to the existence of arsenic in any paper, fabric, or other article offered for sale.

As the most practicable means of forming an opinion as to the extent to which arsenic and arsenical pigments are used at the present time, a large number of samples, of such articles in domestic use as have in former years contained dangerous quantities of arsenic, have been collected and subjected to a careful analysis for arsenic. Papers and fabrics have naturally occupied the most important place in this investigation; for the arsenical pigments used in the manufacture of these materials constitute the most important sources of chronic arsenical poisoning.

In all 1,018 samples have been collected in twenty cities and towns in different sections of the State. Of these, 629, or 61.8 per cent., were non-arsenical; 389, or 38.2 per cent., contained arsenic in appreciable quantities.

The nature of the samples together with the results of the analyses are shown in the following table: —

Nature of Samples.	Non-Arsenical.	Arsenical.	Total.
Wall Papers, ...	44	48	92
Other Papers, ...	79	41	120
Dress Goods, ...	282	174	456
Upholsteries, etc., ...	199	101	300
Candles, ...	18	-	18
Pigments, ...	7	25	32
Total, ...	629	389	1,018

The small number of wall-papers is explained by the fact that the writer was able, as will appear later, to utilize a large number of analyses of such papers made in his private practice.

WALL-PAPERS.

In all the investigations which have been made relative to the use of arsenical pigments, and the dangers which may result from their employment, great prominence has been given to wall-papers. As formerly made, these papers frequently contained a large amount of arsenic which was introduced with the coloring matter. During the past few years, however, the paper manufacturers have strenuously maintained that their goods contain no arsenic except possibly minute traces introduced with clay, glue, or other materials used in this industry; and that, admitting the possibility that injury may have resulted from the use of arsenical papers in the past, no harm can result at the present time unless from exposure to papers which were manufactured and placed on the walls several years ago; finally that, as arsenical papers are not manufactured at the present day, the necessity for legislation has ceased to exist. At the hearing before the Committee on Public Health of the Legislature of 1891, relative to the expediency of some legislation to regulate the manufacture and sale of materials containing arsenic, affidavits were presented from the most prominent manufacturers of wall-paper in this country, in which it was stated that "no arsenic is used in this manufacture, and arsenic forms no part of the materials or ingredients used in such manufacture."

The writer has had exceptional facilities for the investigation of the chemical side of this subject, having examined, during the past thirteen years, several thousand samples of paper for some of the largest dealers in Boston. The analyses made during the first three years of the writer's experience with this work and those made during the three years just past have been brought together, and the results are shown in the following tables: —

Analyses of Wall-papers made in 1879, 1880 and 1881.

YEAR.	Non-Arsenical.	Arsenical.	Total.
1879,	225	151	376
1880,	600	183	783
1881,	475	280	755
Total,	1,300	614	1,914
	67.9%	32.1%	

Analyses of Wall-papers made in 1889, 1890 and 1891.

YEAR.	Non-Arsenical.	Less than one-twentieth grain arsenic per square yard.*	One-twentieth to one-tenth grain per square yard.	Over one-tenth grain per square yard.	Total.
1889,	542	130	33	15	720
1890,	546	197	11	27	781
1891,	365	233	23	20	641
Total,	1,453	560	67	62	2,142
	67.9%	26.1%	3.1%	2.9%	

Before making any comparisons, or drawing any conclusions, it should be said, by way of explanation, that the papers of the earlier series were examined by the original Marsh method, obtaining a mirror on porcelain; while those of the later series were examined by the much more delicate method, the so-called Berzelius-Marsh method.

Had the 1,300 "non-arsenical" papers of the first series been examined by the more delicate process, doubtless a large percentage would have been found to contain an appreciable quantity of arsenic. In other words, the percentage of non-arsenical papers manufactured is probably much

* Estimated as arsenious oxide.

greater to-day than it was ten years ago, although this fact is not apparent from an inspection of the tables.

If a comparison is made between the "arsenical" papers of the first series and those papers of the second series which contain more than one-tenth of a grain per square yard, — and such a comparison is permissible, for the former without any question contained more than this quantity, — we are forced to admit that a very decided improvement has taken place; that about three per cent. of the papers manufactured to-day contain more than one-tenth of a grain of arsenic per square yard, against thirty per cent., approximately, ten years ago.

It may be urged that the improvement in the character of the papers, as *actually sold* in the State, is even greater than these figures indicate, for the reason that the dealers to whom these papers were supplied now return to the manufacturers all which contain more than a certain amount of arsenic. It is to be said, in answer, that the number of dealers who thus return papers is comparatively small; and that such papers as are returned must necessarily find a market elsewhere; that is, with the less particular dealers who constitute the large majority.

In order to determine the character of the papers as sold by other dealers, about 200 samples were collected, some from small dealers in Boston, the majority, however, from dealers in remote parts of the State. Of these 200 samples, 92 were examined with reference to the presence of arsenic; 44 were non-arsenical, 38 contained less than one-twentieth of a grain, 6 between one-twentieth and one-tenth, and 4 more than one-tenth of a grain of arsenic to the square yard. Of the latter, two contained about one-eighth of a grain, one, 1.2 grains, and one, 2.6 grains of arsenic (arsenious oxide) per square yard. There was such a close correspondence between these results and those to which reference has already been made, that it did not seem necessary to pursue this part of the investigation further.

The following conclusions are presented as the result of this inquiry so far as it relates to wall-papers: —

First. Between sixty and seventy per cent. of the papers sold in the State are free from arsenic, while about six per

cent. contain more than one-twentieth of a grain of arsenic (arsenious oxide) per square yard. Of the latter, about one-half, or three per cent. of the whole number, contain more than one-tenth of a grain per square yard.

Second. The percentage of papers containing more than one-tenth of a grain of arsenic per square yard has not diminished during the past three years. The evidence of this is found in the table showing the results of the analyses made in 1889, 1890 and 1891.

Third. It is practicable to manufacture papers which shall contain less than one-twentieth to one-tenth grain of arsenic per square yard. This is evident from the fact that ninety per cent., approximately, of the papers made to-day and sent into the State contain less than this quantity of arsenic.

Fourth. Arsenic is not essential to the production of the colors, since all the colors which have in years past been highly arsenical are now produced without the use of arsenic.

Fifth. The claim of the paper manufacturers that the arsenic present in their products is an unavoidable impurity is not borne out by the facts. About two per cent. of the papers examined contained quantities of arsenic ranging from one-third of a grain to one grain and over per square yard. Such quantities cannot be attributed to unavoidable impurities. It is undoubtedly true that the manufacturers do not knowingly use arsenic. They do use pigments which contain unnecessary quantities of arsenic, and the use of such pigments can easily be avoided.

Other Papers.

Of these, the most important are the so-called "glazed and plated" papers, which may be found in nearly all the Kindergarten schools, where they are placed in the hands of small children who fashion them into ornamental articles of various kinds. Rolls of these papers, put up expressly for the use of children, may be bought in nearly all the toy shops. They are also used for covering pasteboard boxes, as covers for pamphlets, for wrapping confectionery and various fancy articles, for lamp shades, and for decorative purposes.

Many of these papers, as sold to-day, are highly arsenical notwithstanding the fact that their dangerous character has been repeatedly pointed out. Eighty-eight samples, comprising all the colors, have been examined. Of these, 61 were non-arsenical, 19 contained less than one-tenth of a grain of arsenic per square yard, while 8 contained more than one-half grain per square yard. The latter included one blue, one red, one orange, and five arsenical-green (Paris green) papers. Six rolls of these papers were purchased in as many different toy shops, and all, with a single exception, contained a sheet of the characteristic arsenical-green paper. These green papers are unquestionably the most dangerous arsenical papers made. A number of analyses are given in the report of Dr. Wood in the Massachusetts State Board of Health report for 1885, from which it appears that they may contain from three to eight grains of arsenious oxide per square foot. A decided improvement is noticed in other colors, especially the reds. This is probably attributable to the general improvement which has been made in colors in order to meet the requirements of the wall-paper manufacturers. In 1881 the writer examined a large number of these papers, including sixteen reds of various shades. Of the latter eleven were very arsenical, while but one was entirely free from arsenic; while of nine red papers examined for this investigation, five were non-arsenical; one only containing more than one-tenth of a grain per square yard.

Paris green was formerly used a great deal as a pigment for tickets, price cards, and other articles made of cardboard. It has now been replaced to a considerable extent by other less injurious pigments, but its use has not been entirely done away with. Articles of this description, colored with Paris green, are frequently brought to the chemists' notice.

Thin tissue paper of various colors is very much used at the present time for making dolls' dresses, artificial flowers, lamp shades, and for numerous other purposes. Thirty-two samples, many of them shades of red and green, were examined. Eighteen were non-arsenical, 14 contained extremely minute traces of arsenic. The largest amount

found (in two samples only) was approximately one-seventy-fifth of a grain per square yard. These papers, so far as has been observed, do not contain any injurious amount of arsenic.

TEXTILE FABRICS.

Compounds of arsenic are used quite extensively in the manufacture of coloring matters, and in some of the processes for fixing colors upon fabrics. These applications have been well illustrated in the report of Dr. Wood, to which reference has already been made, and it is therefore unnecessary to dwell upon them at this time.

The more important question, just now, is: What percentage of fabrics contain such an amount of arsenic as may, under suitable conditions, cause injury to health? No very thorough investigation of this question appears to have been undertaken. In order, therefore, to get at the facts as exactly as possible, a relatively large number of samples have been examined. In the collection of these samples, a special endeavor has been made to secure as wide a variety in coloring as possible. The results of the analyses are shown in the following table: —

Results of Analyses of Fabrics.

NATURE OF SAMPLES.	Non-Arsenical.	Under one-twentieth grain per square yard.	One-twentieth to one-tenth grain per square yard.	Above one-tenth grain per square yard.	Total.
House Furnishings,*	199	43	8	50	300
Prints and Ginghams,	221	87	19	66	393
Woollens, ...	33	-	-	-	33
Silks, ...	28	2	-	-	30
Total, . . .	481	132	27	116	756

Approximately sixty per cent. of the cotton fabrics were non-arsenical, while about eighteen per cent. contained more

* These included cretonnes, mulls, plushes, corduroys, challies, carpets, etc.

than one-tenth of a grain of arsenic per square yard; a very large proportion of the latter containing much more than this amount. The quantity of arsenic was estimated in twenty samples taken at random from the most arsenical ones, and was found to range between .8 grain and 3.4 grains per square yard. These results are in close correspondence with those obtained by Mr. A. W. Stokes ("Therapeutic Gazette," January, 1889, page 24, from the "London Chemical News"), who examined 100 samples of Indian muslins and cretonnes, and found that twenty-three per cent. contained arsenic in appreciable quantities, the highest percentage being 2.1 grains of arsenious oxide per square yard. The most dangerous material met with was arsenical-green (Paris green) tarlatan, which is still sold in the retail stores, notwithstanding the fact that attention has repeatedly been called to its poisonous character. The pigment is applied to this material very loosely, and is readily detached by friction or even by slight motion. Another very arsenical material, for which there appears to be a considerable demand, is a red striped ticking used for mattresses. Of six samples of this, obtained from different furniture dealers, five proved to contain a very large percentage of arsenic. Here, as in the case of papers, it is apparent that it is practicable to manufacture fabrics which shall be free from arsenic; further, that arsenic is not essential, since there was found for nearly every arsenical sample a duplicate in color which was non-arsenical, and which stood washing equally well with the arsenical pattern.

A few experiments have been made to determine the effect of washing upon the amount of arsenic. It was found in all the experiments that an appreciable amount of arsenic is removed by a single washing; usually about one-half of all the arsenic present. Repeated washings failed, in three experiments in which its effects were investigated, to remove *all* the arsenic.

But little attention has been given to woollens and silks. The results of the few analyses made are in close accord with the previous experience of the writer and other chemists. Occasionally a very arsenical all-wool material is met with, but the percentage of such appears to be very small. Mixed

cotton and woollen goods are, however, as liable to contain arsenic as any cotton fabric. Some of the most arsenical samples met with in this investigation were of this description. The writer has never detected a dangerous amount of arsenic in a pure silk. The percentage of arsenical silks appears to be even smaller than that of arsenical woollens.

MISCELLANEOUS.

The colors used in the interior decorating of houses have been examined with reference to the presence of arsenic, since it appears probable that these, next to papers and fabrics, are the most important sources of chronic arsenical poisoning.

The following were found to contain arsenic in considerable quantity: Orange chrome yellow, two samples; dark ochre, two samples; venetian red, four samples; raw umber, three samples; sienna, two samples; brown umber, two samples. The following were non-arsenical: Chrome green, three samples; emerald green, two samples; whiting, one sample; ultramarine blue, two samples; lampblack, two samples. The remaining colors examined, namely, quaker green, lemon chrome yellow, cobalt blue, and light ochre, contained a small percentage of arsenic.

It is perhaps doubtful if these arsenical pigments, when put on with oil, are likely to cause injury. With water colors, however, the conditions correspond very closely to those met with in the case of wall-papers. These colors are laid on the wall comparatively loose; particles are easily detached, fall to the floor, and may afterward become diffused through the air in the form of a fine dust.

No accurate determination of the amount of arsenic in any of these pigments has been made, for a knowledge of the percentage of arsenic is of no particular value, unless the weight of the pigment used in the preparation of the various tints is also known. It is intended, if possible, to secure the co-operation of some of the decorators in the further investigation of this subject.

So far as could be ascertained Paris green is not used at the present time in the interior decorating of houses. All

the green colors which were tested were either chrome greens, or mixtures of blue and yellow colors.

Several boxes of water colors, such as are used by children, were examined with special reference to the presence of Paris green, but with a negative result.

A similar negative result attended the examination of 18 toy candles which were obtained from different localities. The coloring matter of the green candles was, in all those examined, a mixture of a blue and yellow pigment.

So far as has been observed, Paris green is not now used as a pigment for children's toys, except in the form of the green papers, to which attention has been called, and green tarlatan. Considering the wide publicity which has been given to the whole subject of arsenical poisoning as it may occur in our homes, it is a matter of surprise that this very dangerous arsenical pigment is still used at all in the manufacture of materials which are especially liable to fall into the hands of small children, who are thus subjected to the risk of serious if not fatal poisoning.

Method of Analysis.

In the analysis of papers for arsenic, the method adopted is one which has been used by the writer and other chemists in this vicinity for several years past with perfectly satisfactory results. The following is a brief description of the process: The paper, cut into small pieces, is placed in a porcelain evaporating dish and thoroughly moistened with a few cubic centimeters of concentrated sulphuric acid to which one-thirtieth of its volume of concentrated nitric acid has been added. The mixture is allowed to stand till the paper has absorbed the acid and become thoroughly disintegrated, when the dish is placed on a sand-bath and heated by a low flame with constant stirring till the paper is thoroughly charred and the nitric acid expelled. When the charred mass has cooled, a few cubic centimeters of water are added, the mass is thoroughly pulverized with a glass rod flattened at one end, heated to boiling to expel sulphur dioxide, then filtered and washed with water. The quantity of water used for extraction should not much exceed 30 cubic centimeters (about one fluid ounce).

This method of treatment is applicable to cotton fabrics as well as to papers. Woollens and silks require a slight modification of the process. These, when treated in the manner described with concentrated acids furnish a dark-colored, more or less fluid, mixture, which upon further heating fails to assume the dry granular appearance which is essential to the securing of a clear extract upon treatment with water. If this colored mixture is treated with water and filtered, a great deal of the organic matter passes through the paper, and the dark colored extract thus obtained is unsuitable for the subsequent test. In such cases satisfactory results have been secured by heating the material, as before described, with the concentrated acids till the nitric acid is expelled, and then adding, after the mixture has cooled somewhat, the proper quantity of paper which has previously been proved to be free from arsenic, and reheating. The mixture then readily assumes a dry granular appearance and upon treatment with water furnishes a clear extract.

The extract, obtained in the manner described, is tested for arsenic by the modification of the Marsh method known as the Berzelius-Marsh method. A failure to obtain a mirror within twenty-five to thirty minutes is regarded as proof of the absence of arsenic. All materials used in the process must be absolutely free from arsenic, and the mirror when obtained must be carefully tested in order to avoid any error which might result from the presence of antimony.

By means of the Berzelius-Marsh method, comparing the mirror obtained from an aliquot part of a solution obtained from a measured amount of paper or fabric with a set of standard mirrors obtained from known amounts of arsenious oxide, the amount of arsenic present can be easily and quickly estimated. This method for the quantitative estimation of arsenic was first suggested by Prof. H. B. Hill of Cambridge, and has since been worked out by Prof. C. R. Sanger, whose investigations are published in the Proceedings of the American Academy of Arts and Sciences, Vol. XXVI. Professor Sanger finds that it furnishes, when carried out with proper precautions, results worthy of comparison with other methods; and that it unquestionably

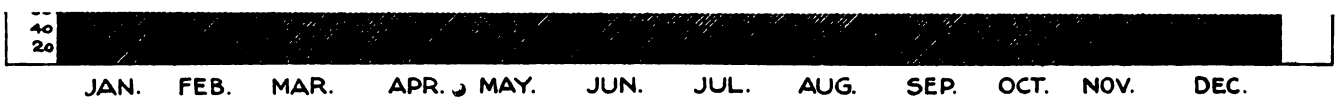
surpasses all other methods for the quantitative estimation of minute quantities of arsenic.

The amount of paper or fabric taken for analysis has varied somewhat with the character of the material; e. g., whether a plain color or figured. Usually 100 square centimeters (about 16 square inches), occasionally 200 square centimeters, have been taken. In the case of figured materials, it is important to secure all the colors in fair proportion. This can be effected by the use of patterns of different dimensions.

WILLIAM B. HILLS.

BOSTON, Jan. 28, 1892.

MORTALITY REPORTS.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THE WEEKLY MORTALITY REPORTS OF MASSACHUSETTS CITIES AND TOWNS FOR THE YEAR 1891.

The following report comprises the statistics which have been compiled from the returns sent to the Board at the close of each week by the authorities of cities and towns having in charge the registration of the vital statistics of their respective municipalities. These returns are entirely voluntary, and consist chiefly of the mortality returns of the cities and of the large towns in which the registration is most efficiently conducted. It would add very much to the value of this report if every town in the State should contribute to it. Legislation has repeatedly been recommended which should secure this result, but thus far without avail. Hence the report must for the present be incomplete. Its value, when compared with the registration reports of the State, lies in the fact that it presents with a tolerable degree of accuracy the seasonable fluctuation of the principal infectious diseases from year to year.

The estimated population of the cities and towns contributing to this report for the year 1891 was about 1,200,000, or one-half the population of the State.

The data embraced in this report are the following: —

Average height of barometer for each week.
Mean or daily maximum temperature.
Mean or daily minimum temperature.
Rainfall expressed in inches.
Total deaths for each week reported.
Deaths of children under five years
Deaths from infectious diseases.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet-fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from small-pox.
Deaths from erysipelas.

The following points are to be observed in regard to this summary of weekly mortality reports of the State: —

1. It is not a report of the entire population, since it is compiled mainly from the returns of the cities and large towns, comprising about three-fifths of the population.

2. It does not correspond exactly with the calendar year, since it is made up from weekly and not from monthly returns. In that portion which gives the mortality for nine years, the weeks of the different years do not correspond exactly. The summary must be regarded as an approximate statement.

3. The death rates in these reports are probably in each year slightly greater than those of the State, since they mainly represent the mortality of an urban population.

In addition to the statistics of the year 1891, the present report will contain a summary of the reported weekly mortality of the previous eight years, 1883–90 inclusive.

General Summary.

DATE.		Barometer.	Maximum Thermometer for each Week.	Minimum Thermometer for each Week.	Rain—Inches.	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diarrhœal Diseases.	Scarlet-fever.	Measles.	Diphtheria and Croup.	Whooping-cough.	Malarial Fever.	Small-pox.	Erysipelas.	Puerperal Fever.	Death Rate per 1,000.
Jan.	3,	29.99	29	13	1.55	461	129	52	80	16	4	6	3	19	-	-	-	2	2	19.45
	10,	30.14	31	18	.35	480	146	75	93	14	5	3	1	14	2	1	-	-	1	20.08
	17,	30.09	37	22	1.09	518	165	58	87	23	2	7	5	19	2	1	-	3	-	21.37
	24,	29.99	42	29	2.81	443	130	57	75	15	6	3	3	9	1	-	-	2	-	18.29
	31,	30.02	39	29	1.18	430	125	54	69	5	9	1	1	9	3	-	-	2	1	16.55
Feb.	7,	30.03	40	23	.96	458	150	59	73	8	4	3	1	7	3	-	-	4	1	19.25
	14,	30.17	33	21	1.58	426	120	55	76	9	7	3	-	8	3	-	-	-	-	18.21
	21,	30.05	41	25	.59	411	126	41	74	7	4	5	5	7	1	-	-	4	-	19.25
	28,	30.01	43	28	2.11	448	144	49	93	10	1	8	4	9	2	-	-	3	1	19.55
March	7,	30.16	31	16	1.77	445	128	55	82	7	6	4	2	9	2	-	-	4	1	20.31
	14,	30.08	45	32	1.60	454	118	60	89	7	10	-	2	5	2	-	-	1	1	19.27
	21,	30.16	39	26	.08	426	124	48	71	7	2	4	3	7	2	-	-	1	-	19.58
	28,	30.11	44	33	2.18	389	115	37	60	8	7	7	4	11	-	-	-	1	-	20.28
April	4,	29.88	42	34	1.83	502	124	69	92	12	2	2	-	4	1	-	-	1	-	21.39
	11,	30.16	46	32	-	446	116	62	86	6	7	2	2	10	4	-	-	3	1	20.30
	18,	30.08	58	45	.91	520	146	57	106	5	6	2	4	6	2	-	-	4	2	22.21
	25,	29.85	66	44	.26	425	122	51	91	6	4	6	1	12	3	-	-	5	1	19.34
May	2,	29.84	64	43	-	508	135	67	99	6	3	6	-	7	-	-	-	2	-	21.68
	9,	29.95	57	41	.10	428	118	58	68	2	3	7	5	11	1	-	-	2	-	19.45
	16,	29.99	67	48	-	458	114	64	96	6	8	3	2	6	2	-	-	4	1	21.03
	23,	30.11	68	49	1.43	473	131	70	91	4	9	2	1	13	2	-	-	2	-	21.12
	30,	30.08	66	49	.52	400	104	46	85	4	9	2	-	10	-	-	-	6	1	19.02
June	6,	30.03	68	50	.88	377	103	59	62	4	6	3	2	11	1	-	-	1	1	16.96
	13,	30.04	82	59	-	400	125	51	61	-	12	1	2	8	-	-	-	2	1	17.19
	20,	29.89	74	58	1.15	462	151	57	53	3	29	1	3	9	-	-	-	2	1	20.84
	27,	29.85	71	59	1.98	378	151	44	48	2	40	1	3	9	1	-	-	2	1	15.66
July	4,	29.91	71	57	.23	353	133	51	27	3	40	2	5	12	-	-	-	-	-	15.94
	11,	29.96	74	61	56	472	228	61	23	2	105	1	6	4	1	1	1	1	-	19.64
	18,	30.02	71	66	.07	591	276	33	42	4	162	1	3	7	-	-	-	-	-	24.96
	25,	30.13	79	63	1.01	620	368	59	17	8	228	-	1	2	2	-	-	2	-	26.41
Aug.	1,	29.94	72	58	1.60	637	371	71	17	5	228	1	1	8	2	-	-	-	1	28.06
	8,	30.02	76	61	.80	559	320	43	21	6	153	4	-	5	3	-	-	-	-	24.58

THE WEEKLY MORTALITY REPORTS OF MASSACHUSETTS CITIES AND TOWNS FOR THE YEAR 1891.

The following report comprises the statistics which have been compiled from the returns sent to the Board at the close of each week by the authorities of cities and towns having in charge the registration of the vital statistics of their respective municipalities. These returns are entirely voluntary, and consist chiefly of the mortality returns of the cities and of the large towns in which the registration is most efficiently conducted. It would add very much to the value of this report if every town in the State should contribute to it. Legislation has repeatedly been recommended which should secure this result, but thus far without avail. Hence the report must for the present be incomplete. Its value, when compared with the registration reports of the State, lies in the fact that it presents with a tolerable degree of accuracy the seasonable fluctuation of the principal infectious diseases from year to year.

The estimated population of the cities and towns contributing to this report for the year 1891 was about 1,200,000, or one-half the population of the State.

The data embraced in this report are the following: —

Average height of barometer for each week.
Mean or daily maximum temperature.
Mean or daily minimum temperature.
Rainfall expressed in inches.
Total deaths for each week reported.
Deaths of children under five years
Deaths from infectious diseases.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet-fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from small-pox.
Deaths from erysipelas.

The following points are to be observed in regard to this summary of weekly mortality reports of the State: —

1. It is not a report of the entire population, since it is compiled mainly from the returns of the cities and large towns, comprising about three-fifths of the population.

2. It does not correspond exactly with the calendar year, since it is made up from weekly and not from monthly returns. In that portion which gives the mortality for nine years, the weeks of the different years do not correspond exactly. The summary must be regarded as an approximate statement.

3. The death rates in these reports are probably in each year slightly greater than those of the State, since they mainly represent the mortality of an urban population.

In addition to the statistics of the year 1891, the present report will contain a summary of the reported weekly mortality of the previous eight years, 1883–90 inclusive.

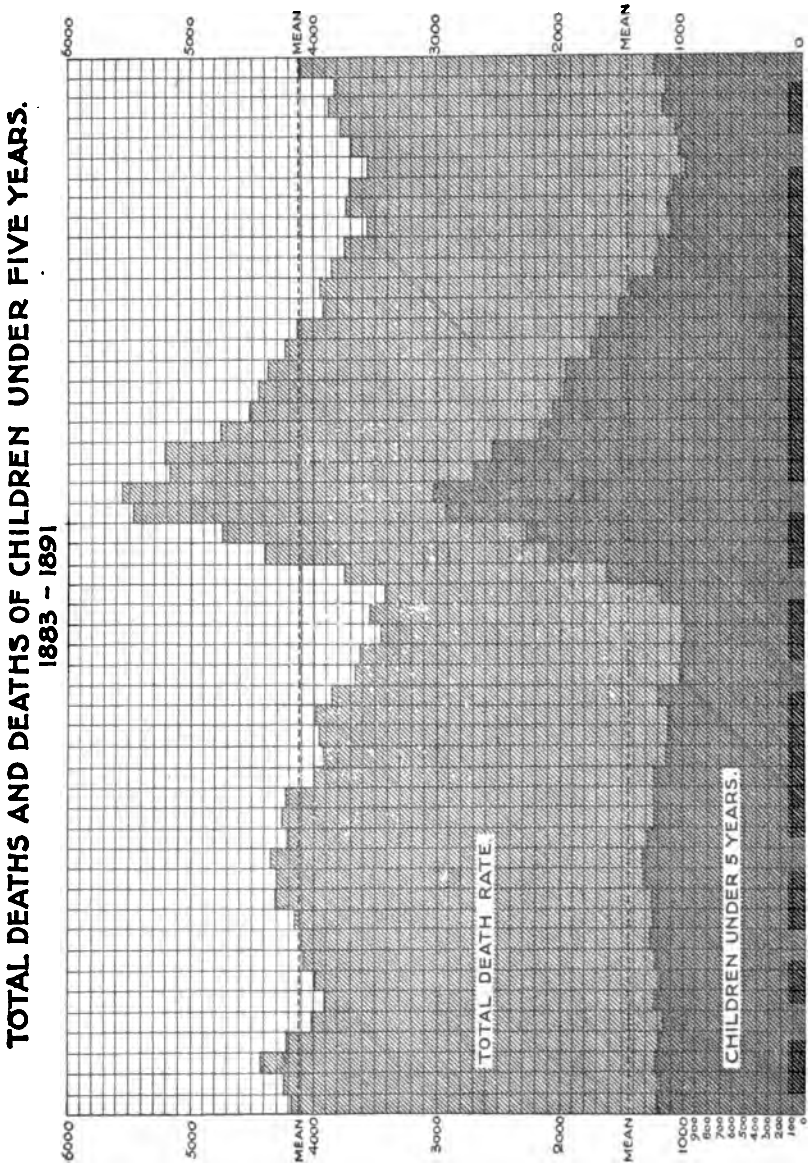
General Summary.

DATE.		Barometer.	Maximum Thermometer for each Week.	Minimum Thermometer for each Week.	Rain—Inches.	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diarrhœal Diseases.	Scarlet-fever.	Measles.	Diphtheria and Croup.	Whooping-cough.	Malarial Fever.	Small-pox.	Erysipelas.	Puerperal Fever.	Death Rate per 1,000.
Jan.	3,	29.99	29	13	1.55	461	129	52	80	16	4	6	8	19	-	-	-	2	2	19.45
	10,	30.14	31	18	.35	480	146	75	93	14	5	8	1	14	2	1	-	-	1	20.08
	17,	30.09	37	22	1.09	518	165	58	87	23	2	7	5	19	2	1	-	8	-	21.37
	24,	29.99	42	29	2.81	443	130	57	75	15	6	8	8	9	1	-	-	2	-	18.29
	31,	30.02	39	29	1.18	430	125	54	69	5	9	1	1	9	3	-	-	2	1	16.55
Feb.	7,	30.03	40	23	.96	458	150	59	73	8	4	3	1	7	8	-	-	4	1	19.25
	14,	30.17	33	21	1.58	426	120	55	76	9	7	3	-	8	8	-	-	-	-	18.21
	21,	30.05	41	25	.59	411	126	41	74	7	4	5	5	7	1	-	-	4	-	19.25
	28,	30.01	43	28	2.11	448	144	49	93	10	1	8	4	9	2	-	-	8	1	19.55
March	7,	30.16	31	16	1.77	445	128	55	82	7	6	4	2	9	2	-	-	4	1	20.31
	14,	30.08	45	32	1.60	454	118	60	89	7	10	-	2	5	2	-	-	1	1	19.27
	21,	30.16	39	26	.08	426	124	48	71	7	2	4	3	7	2	-	-	1	-	19.58
	28,	30.11	44	33	2.18	389	115	37	60	8	7	7	4	11	-	-	-	1	-	20.28
April	4,	29.88	42	34	1.83	502	124	69	92	12	2	2	-	4	1	-	-	1	-	21.39
	11,	30.16	46	32	-	446	116	62	86	6	7	2	2	10	4	-	-	8	1	20.30
	18,	30.08	58	45	.91	520	146	57	106	5	6	2	4	6	2	-	-	4	2	22.21
	25,	29.85	66	44	.26	425	122	51	91	6	4	6	1	12	8	-	-	5	1	19.34
May	2,	29.84	64	43	-	508	135	67	99	6	3	6	-	7	-	-	-	2	-	21.68
	9,	29.95	57	41	.10	428	118	58	68	2	8	7	5	11	1	-	-	2	-	19.45
	16,	29.99	67	48	-	458	114	64	96	6	8	8	2	6	2	-	-	4	1	21.03
	23,	30.11	68	49	1.43	473	131	70	91	4	9	2	1	18	2	-	-	2	-	21.12
	30,	30.08	66	49	.52	400	104	46	85	4	9	2	-	10	-	-	-	6	1	19.02
June	6,	30.08	68	50	.88	377	103	59	62	4	6	3	2	11	1	-	-	1	1	16.96
	13,	30.04	82	59	-	400	125	51	61	-	12	1	2	8	-	-	-	2	1	17.19
	20,	29.89	74	58	1.15	462	151	57	53	8	29	1	8	9	-	-	-	2	1	20.84
	27,	29.85	71	59	1.98	378	151	44	48	2	40	1	8	9	1	-	-	2	1	15.66
July	4,	29.91	71	57	.23	353	133	51	27	3	40	2	5	12	-	-	-	-	-	15.94
	11,	29.96	74	61	56	472	228	61	23	2	105	1	6	4	1	1	1	1	-	19.64
	18,	30.02	71	66	.07	591	276	33	42	4	162	1	8	7	-	-	-	-	-	24.96
	25,	30.13	79	63	1.01	620	368	59	17	8	228	-	1	2	2	-	-	2	-	26.41
Aug.	1,	29.94	72	58	1.60	637	371	71	17	5	228	1	1	8	2	-	-	-	1	28.06
	8,	30.02	76	61	.80	559	320	43	21	6	153	4	-	5	8	-	-	-	-	24.58

General Summary — Concluded.

DATE.		Barometer.	Maximum Thermometer for each Week.	Minimum Thermometer for each Week.	Rain — Inches.	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diarrhœal Diseases.	Scarlet-fever.	Measles.	Diphtheria and Croup.	Whooping-cough.	Malarial Fever.	Small-pox.	Erysipelas.	Puerperal Fever.	Death Rate per 1,000.
Aug.	15,	29.98	80	66	.32	648	346	41	20	5	134	1	-	6	2	1	-	-	3	27.64
	22,	29.94	78	65	.60	502	249	54	16	5	129	1	-	6	2	-	-	-	-	28.30
	29,	30.03	77	64	1.80	518	246	53	14	8	154	1	-	12	4	-	-	1	1	23.22
Sept.	5,	30.16	69	58	.52	487	237	55	22	9	120	1	-	4	1	-	-	1	1	21.26
	12,	30.14	74	57	2.83	488	235	51	17	13	98	2	1	6	2	-	-	-	-	20.80
	19,	30.08	75	59	.10	440	189	49	19	13	84	1	-	12	1	-	-	-	-	21.19
	26,	30.16	75	62	-	503	221	55	15	22	67	1	1	7	-	-	-	-	-	21.15
Oct.	3,	30.21	74	57	.12	446	192	51	22	14	60	1	1	11	1	1	-	-	-	20.57
	10,	30.03	60	49	2.52	502	221	64	28	6	63	-	1	11	4	-	-	-	2	21.15
	17,	30.21	56	43	1.39	485	178	50	34	18	37	-	-	12	2	1	-	1	-	22.04
	24,	29.86	52	41	1.66	455	134	69	35	21	25	5	-	15	-	-	-	-	-	19.17
	31,	30.03	55	39	.13	414	135	55	47	13	16	3	-	28	-	-	-	-	-	18.49
Nov.	7,	30.15	45	33	-	443	124	51	52	14	11	3	-	27	3	-	-	-	-	18.91
	14,	30.19	53	40	.32	455	149	46	54	11	11	2	-	21	3	-	-	3	1	19.01
	21,	30.45	49	33	.93	445	117	63	69	11	12	4	1	16	2	-	-	-	1	18.69
	28,	29.86	52	39	1.45	465	145	47	70	7	10	6	-	27	1	-	-	1	-	19.99
Dec.	5,	30.24	45	29	.36	470	134	62	82	12	4	4	-	15	-	-	-	-	1	20.61
	12,	30.04	52	38	.40	497	147	66	97	9	4	5	-	20	-	-	-	1	-	21.00
	19,	29.99	41	27	.52	532	138	58	100	7	8	8	-	25	3	-	-	2	-	22.94
	26,	30.18	49	38	1.24	694	178	64	185	7	5	10	-	23	4	-	-	1	-	29.95
Total,		-	-	-	48.39	24,687	8,771	2,877	3,205	449	2,173	155	80	591	83	6	1	77	29	-
Weekly average,		-	-	-	.93	475	169	55	62	8	42	3	1	11	1	-	-	1	-	20.73
Rate per 1,000 deaths,		-	-	-	-	-	355.3	116.5	129.8	18.19	84.01	6.28	3.24	23.94	3.38	.25	-	3.12	1.18	-
Rate per 1,000 of the estimated reporting population,		-	-	-	-	20.73	7.36	2.42	2.69	.38	1.82	.1	.07	.49	.07	-	-	.06	.02	-

Average reporting population, ... 1,190,637


TOTAL DEATHS AND DEATHS OF CHILDREN UNDER FIVE YEARS.
1883 - 1891
TOTAL DEATH RATE.
CHILDREN UNDER 5 YEARS.
JAN.
FEB.
MAR.
APR.
MAY.
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
6000
5000
MEAN
4000
3000
2000
MEAN
1000
0

Total Deaths.

The whole number of deaths reported for 1891, from the cities and towns which contributed returns, was 24,687, and the average number per week was 475. The greatest number of deaths reported in a single week was 694, in the week ending December 26, and the least number was 353, in the week ending July 4.

The weekly average number of deaths reported for each month was as follows: —

January,	466	July,	509
February,	436	August,	573
March,	428	September,	479
April,	476	October,	460
May,	447	November,	452
June,	404	December,	548

The months in which the greatest numbers of deaths were reported were July, August and December, and those in which the least numbers were reported were February, March and June.

The percentages of mortality in each of the four quarters of the year were as follows: —

	All Ages.		Ages under 5 Years.	
	Numbers.	Percentages.	Numbers.	Percentages.
First quarter,	5,789	23.44	1,720	19.61
Second quarter,	5,777	23.40	1,640	18.70
Third quarter,	6,818	27.62	3,419	38.98
Fourth quarter,	6,303	25.54	1,992	22.71
Total,	24,687	100.00	8,771	100.00

The percentages in each quarter were more uniform than those of 1890, in which year the extremes for all ages were 21.8 and 28.6, while in 1891 the extremes were 23.4 and 27.6.

The appearance of influenza in the winter of 1891–92 seems to have had a similar effect upon the mortality rate to that which was observed two years previous.

Deaths under Five Years.

The reported number of deaths of children under five years of age was 8,771, and the average weekly number was 169. The greatest number reported in a single week was 371, in the week ending August 1; and the least number was 103, in the week ending June 6. The ratio of the deaths of this class to the total reported mortality was 35.5 per cent., being nearly identical with that of 1890, and but slightly greater than those of the preceding years.

The average weekly number of deaths of children under five years of age, by months, was as follows: —

January,	139	July,	251
February,	136	August,	306
March,	121	September,	441
April,	127	October,	172
May,	120	November,	134
June,	132	December,	149

The months having the greatest number of deaths at this period of life were July and August, and those having the least were March and May.

As in previous years, the percentage of deaths of this class in the third quarter of the year very largely exceeded those of either of the other quarters.

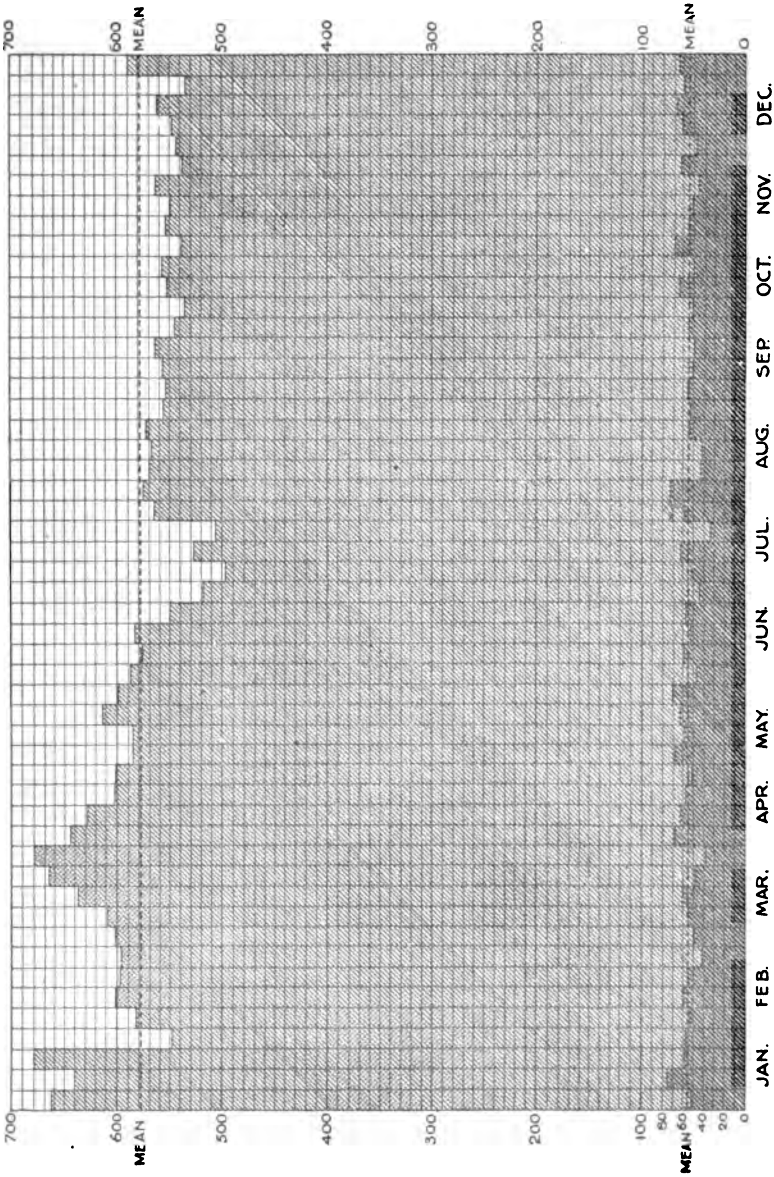
Consumption.

The number of reported deaths from this cause in 1891 was 2,877, and the weekly average 55. The greatest number of deaths reported from this cause in a single week was 75, in the week ending January 10, and the least number was 33, in the week ending July 18. In most of the weeks the variation from the average was but slight.

The average weekly number reported in each month from this cause was as follows: —

January,	59	July,	51
February,	51	August,	52
March,	50	September,	52
April,	59	October,	58
May,	61	November,	51
June,	53	December,	60

CONSUMPTION.



1883 TO 1891 INCLUSIVE.
1891.

Reported Mortality from Consumption for each week, 1891, and for nine years 1883-91.

The variations from the average weekly numbers for the years 1889, 1890 and 1891 were as follows: —

Variation from the Weekly Average.

	1889.	1890.	1891.		1889.	1890.	1891.
January, . .	0	42	4	July, . .	—1	—8	—4
February, .	4	3	—4	August, . .	—1	—4	—3
March, . .	0	3	—5	September, .	—3	—5	—3
April, . .	2	1	4	October, .	0	—11	3
May, . .	—1	1	6	November, .	1	—12	—4
June, . .	—2	—3	—2	December, .	0	0	5

The excessive variation of January, 1890, was attendant upon the epidemic of influenza of that year. The ratio of reported deaths from consumption, as compared with the reported mortality from all causes, was 116.5, while that of previous years was as follows; 1886, 156.5; 1887, 141.1; 1888, 134.2; 1889, 125; and 1890, 130. The ratio to the reporting population was 2.42, as compared with 2.78 in 1890.

Acute Lung Diseases.

The number of reported deaths from this group of causes in 1891 was 3,205, and the average number for each week was 62.

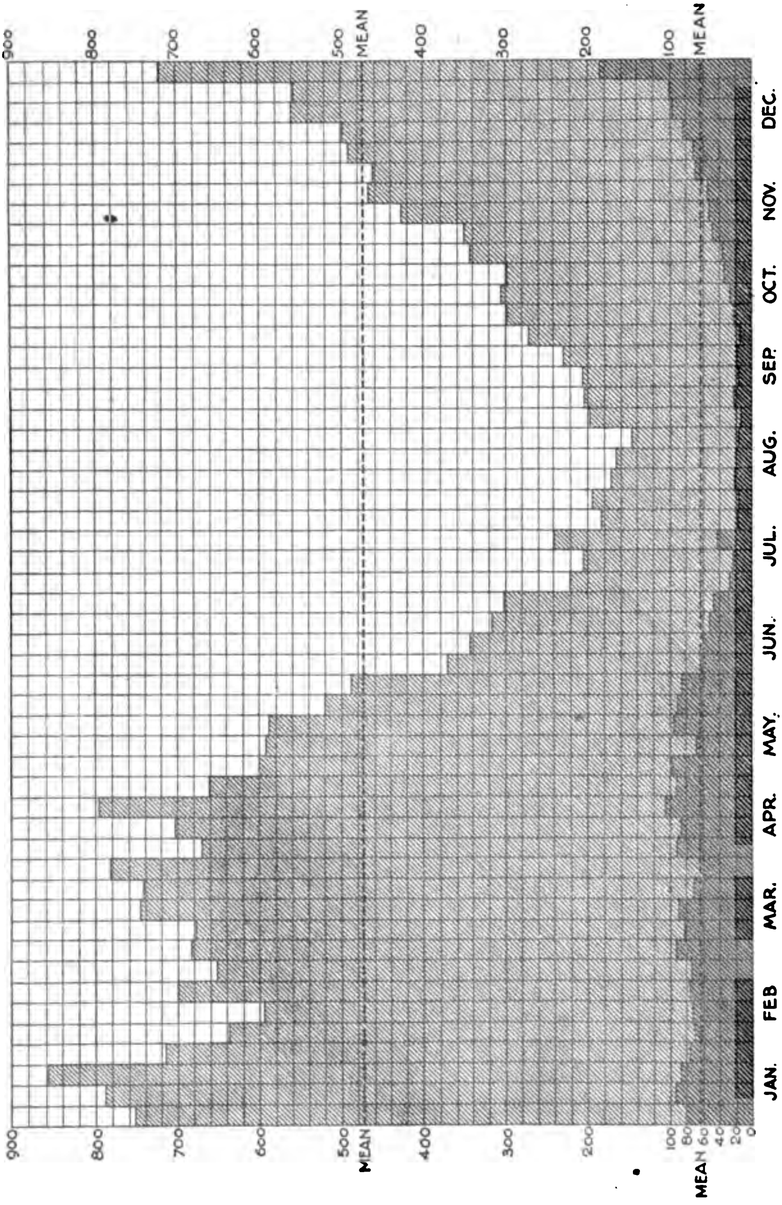
The average weekly number reported for each month was as follows: —

January, ...	81	July, ...	27
February, ...	79	August, ...	19
March, ...	75	September, ...	18
April, ...	94	October, ...	33
May, ...	88	November, ...	61
June, ...	56	December, ...	116

The greatest number of deaths reported from these causes in a single week was 185, in the week ending December 26, and the least number was 14, in the week ending August 29.

The months having the greatest number of reported deaths from these causes were January, May and December, and those having the least number were July, August and Sep-

ACUTE LUNG DISEASES.



1883 TO 1891 INCLUSIVE.
1891.

Reported Mortality from Acute Lung Diseases for each week, 1891 and for nine years. (1883-91)

tember. The effect of another epidemic of influenza began to show itself in a largely increased number of deaths from these causes in the last week of December.

The ratio of reported deaths from these causes, as compared with the reported total mortality, was 129.8 per 1,000, as compared with 130.8 in 1890 and 106 in 1889. The mortality rate, as compared with the reporting population, was 2.69 per 1,000; that of 1890 was 2.8.

Typhoid Fever.

The total number of reported deaths from typhoid fever in 1891 was 449, and the weekly average was 8.

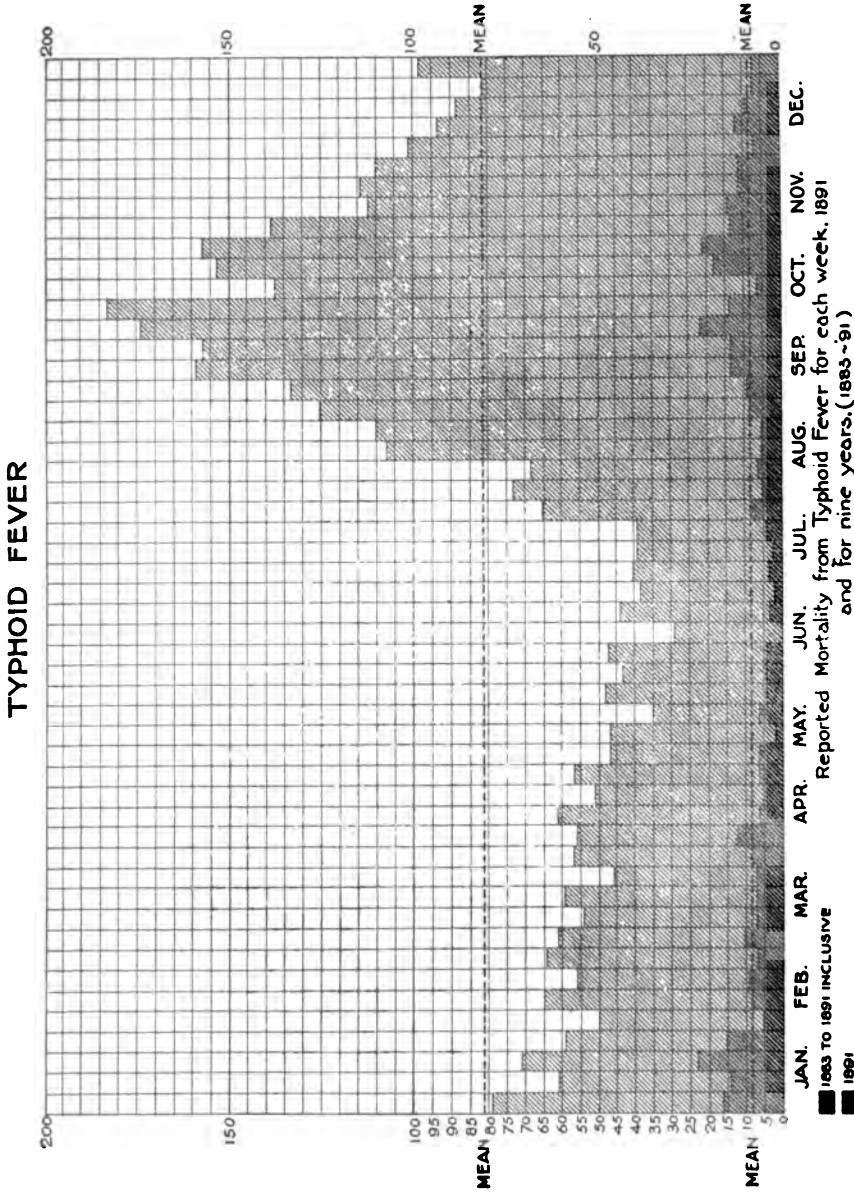
The average weekly number reported for each month was as follows: —

January,	15	July,	4
February,	11	August,	6
March,	7	September,	14
April,	7	October,	15
May,	4	November,	11
June,	2	December,	9

The months having the greatest number of deaths from this cause were January, September and October, and those having the least number were May, June and July. The unusual increase in January and February was mainly due to the prevalence of the disease among the cities of the Merrimack River valley which derive their water supply from that river. (See paper by Mr. Mills, in report of 1890.)

The ratio of reported deaths from typhoid fever to the reported mortality from all causes in 1891 was 18.2 per 1,000, which was less than that of either of the four previous years. That of 1890 was 19.3; 1889, 20.9; 1888, 20.7; and 1887, 20.9. The reduction in the State at large since 1861 has been fully one-half, notwithstanding the continued high prevalence in cities having polluted water supplies. The ratio to the reporting population was .38 per 1,000, while that of 1890 was .42.

The greatest number of reported deaths from this cause (22) occurred in the week ending September 26, and there were no reported deaths from this cause in the week ending June 13.


TYPHOID FEVER
Reported Mortality from Typhoid Fever for each week, 1891
and for nine years, (1883-'91)
1883 TO 1891 INCLUSIVE
1891
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
MEAN
MEAN
200 150 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0

DIARRHŒAL DISEASES. (*Diarrhœa, Dysentery, Cholera, Cholera Infantum and Enteritis*).

The number of deaths reported from this group of causes in 1891 was 2,173, and the weekly average was 42.

The average weekly number reported for each month was as follows: —

January,	5	July,	134
February,	4	August,	160
March,	6	September,	92
April,	5	October,	40
May,	6	November,	11
June,	22	December,	5

The months having the greatest number of deaths from this group of causes were July, August and September, and those having the least were January, February, April and December. The greatest number reported in a single week was 228, in each of the two weeks ending July 25 and August 1; and the least number was 1, in the week ending February 28.

The reported mortality from these causes for the last half of the year was 90.6 of the total number reported for the year from the same causes, and that of the third quarter of the year was 78.3 per cent. The ratio of the reported mortality from these causes to the total mortality was 84. per 1,000, as compared with 89.8 in 1890, 87.7 in 1889 and 77.9 in 1888. The ratio to the reporting population was 1.82 per 1,000.

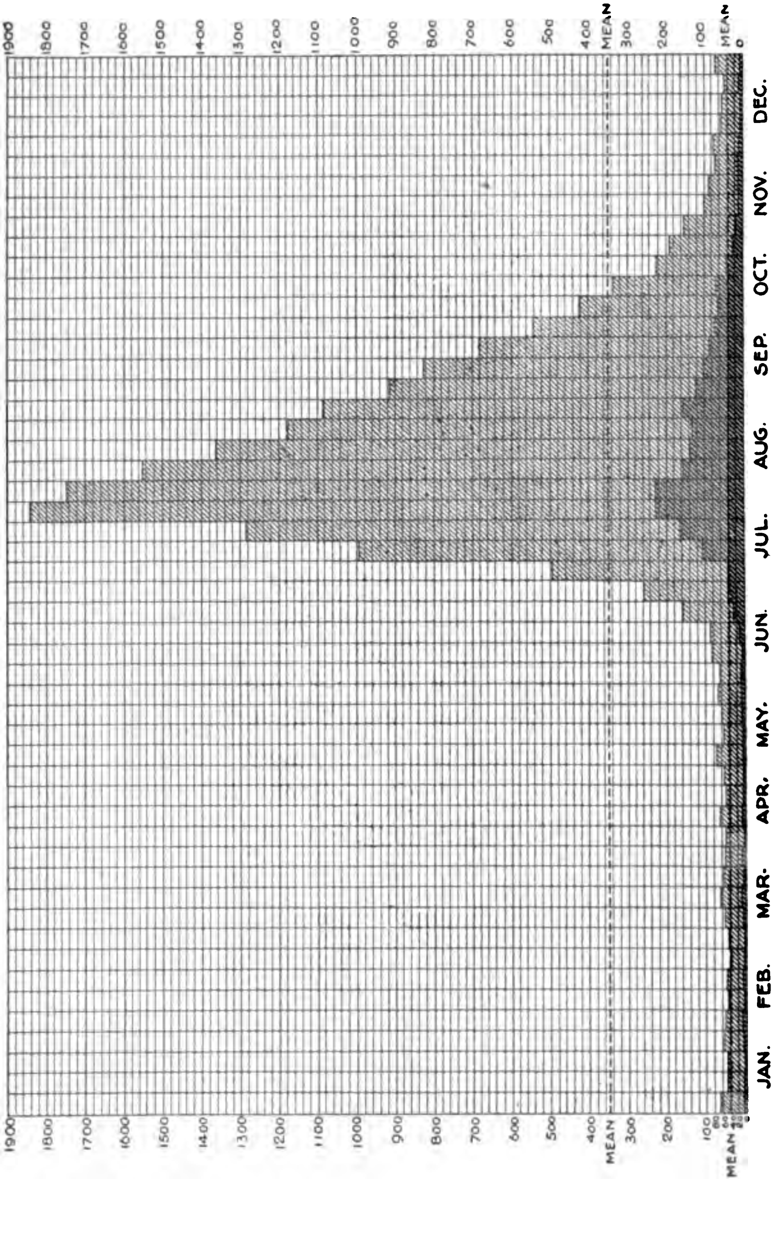
SCARLET-FEVER.

The total number of reported deaths from scarlet-fever in 1891 was 155, and the weekly average from the same cause was 3.

The average reported weekly mortality for each month was as follows: —

January,	4	July,	1
February,	3	August,	2
March,	4	September,	1
April,	3	October,	2
May,	4	November,	4
June,	2	December,	7

DIARRHŒAL DISEASES.



1883 TO 1891 INCLUSIVE.
1891.

Reported Mortality from Diarrhœal Diseases for each week, 1891. and for nine years. (1883-'91)

The months having the greatest reported mortality from this cause were June and December, and those having the least were July and September.

The ratio of the reported mortality from this cause to the total mortality was 6.3 per 1,000, as compared with 4.6 in 1890, 11.2 in 1889 and 14.4 in 1888.

The ratio for the thirty years ending with 1890 was 26.1, and the lowest ratio of any year of that period was 4.4. The actual numbers of deaths from this cause in 1872, '73, '74, '75 and '76 were respectively 1,377, 1,472, 1,382, 1,684 and 1,222.

The greatest number of deaths reported from this cause in a single week was 10, in the week ending December 26, and there were no deaths from this cause in the weeks ending July 25 and October 10 and 17. The ratio to the estimated reporting population was .13 per 1,000.

MEASLES.

The total number of reported deaths from this cause was 80, and the weekly average 1.5. The average weekly mortality reported from this cause was as follows: —

January,	3	July,	3
February,	2	August,	–
March,	3	September,	1
April,	2	October,	–
May,	2	November,	–
June,	2	December,	–

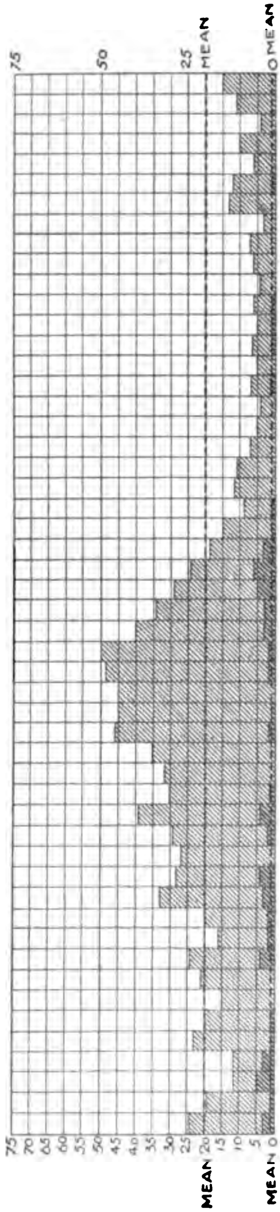
The months having the greatest number of reported deaths from this cause were January, March and July, and the weekly average in August, October, November and December was less than 1.

The ratio of mortality from measles to the total mortality was 3.24 per 1,000, as compared with 1.9 in 1890 and 3.6 in 1889. The ratio to the estimated population of reporting cities and towns was .07 per 1,000.

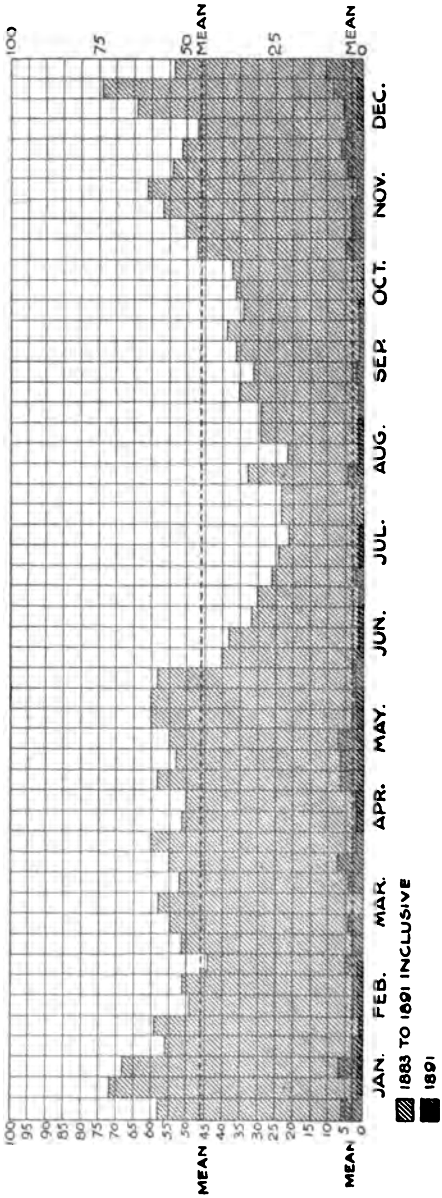
DIPHTHERIA AND CROUP.

The total number of deaths reported from diphtheria and croup was 591, and the weekly average was 11.

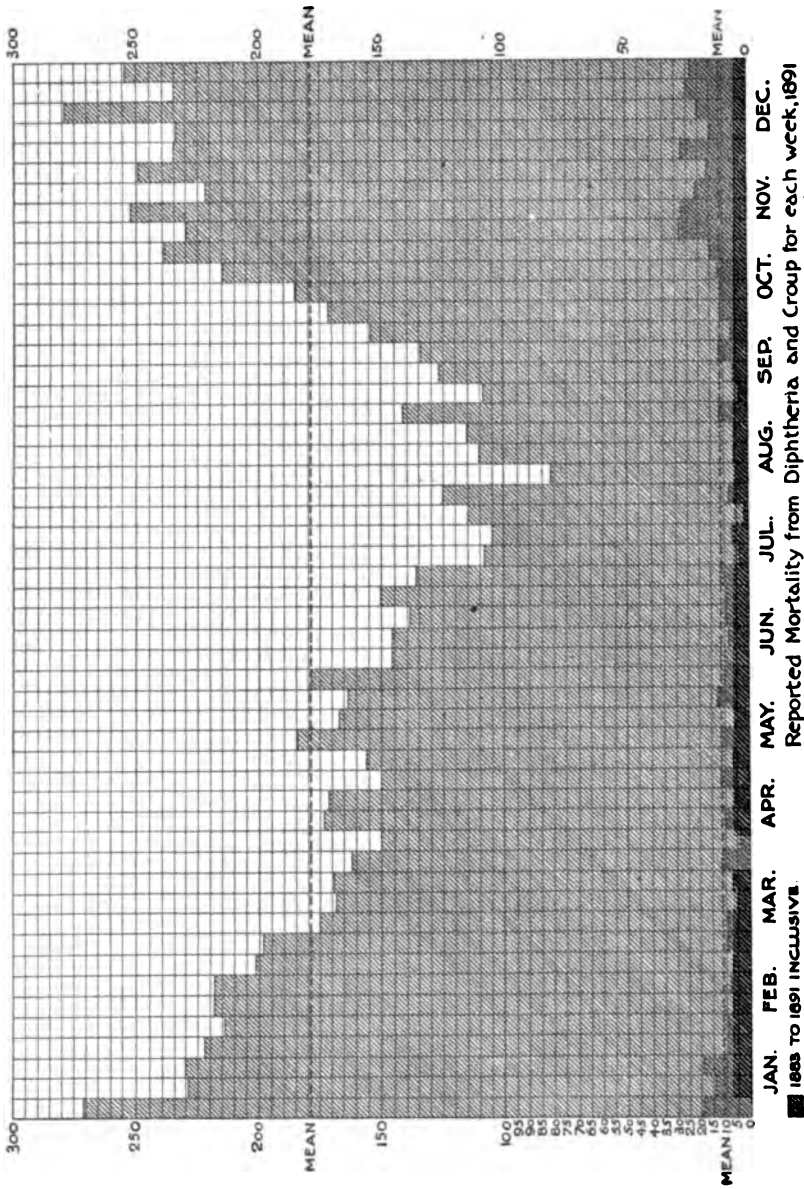
MEASLES.



SCARLET FEVER.



DIPHTHERIA AND CROUP.



Reported Mortality from Diphtheria and Croup for each week, 1891
and for nine years, (1883–1891)

The average weekly mortality reported in each month was as follows: —

January,	14	July,	6
February,	8	August,	7
March,	8	September,	7
April,	8	October,	15
May,	9	November,	23
June,	9	December,	21

The greatest number of reported deaths occurred in the months of October, November and December, and the least number in July, August and September.

The greatest number of deaths reported from these causes in a single week (28) occurred in the week ending October 31, and the least number (2) in the week ending July 25.

The ratio of mortality from diphtheria and croup to the total reported mortality was 23.9 per 1,000, as compared with 37.9 in 1890, 56.9 in 1889 and 53.6 in 1888.

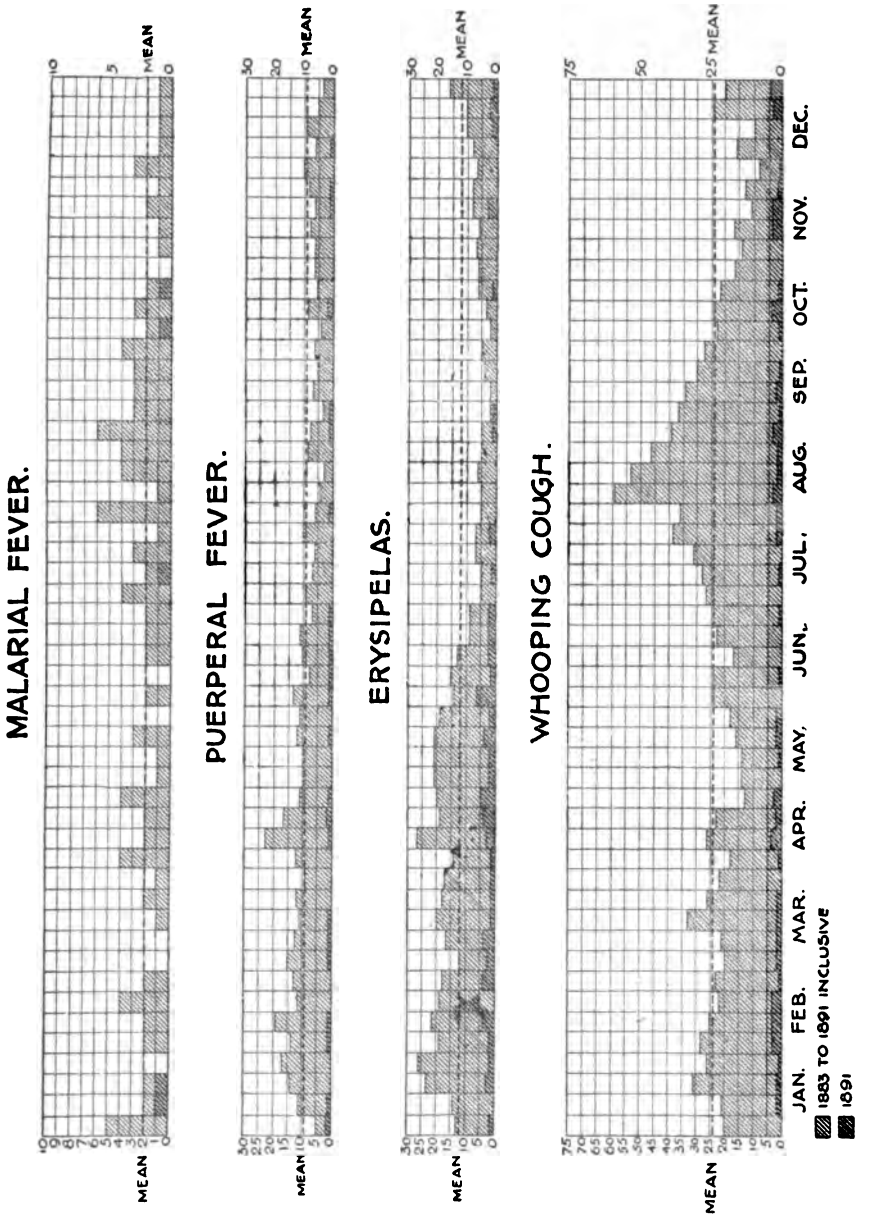
The ratio to the estimated reporting population was .5 per 1,000.

Whooping-cough, Erysipelas, Puerperal Fever, Malarial Fever and Small-pox.

The statistics relative to this group of causes of death are shown in the following table: —

	Total Deaths reported.	Weekly Average.	Ratio per 1,000 reported Deaths from all Causes.	Ratio per 1,000 of the Estimated Population.
Whooping-cough,	83	1.6	3.4	.07
Erysipelas,	77	1.5	3.1	.06
Puerperal fever,	29	0.6	1.2	.02
Malarial fever,	6	0.1	0.2	.004
Small-pox,	1	-	-	-

The reported mortality from whooping-cough was less than that of any of the preceding years since the beginning of publication of the summary of the weekly mortality reports. The


MALARIAL FEVER.
PUERPERAL FEVER.
ERYSIPELAS.
WHOOPING COUGH.
MEAN
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
1883 TO 1891 INCLUSIVE
1891

reported deaths from erysipelas and puerperal fever were greater than those of 1890, and those from malarial fever were less. There was but one reported death from small-pox in 1891.

SUMMARY FOR THE NINE YEARS 1883 to 1891 INCLUSIVE.

In addition to the foregoing statistics of reported mortality for the year 1891, the figures for the whole period of nine years during which these reports have been issued are presented in the following tables. The chief value of these tables consists in the fact that they present the seasonal mortality from several of the most destructive and infectious diseases for a considerable period of time. The causes of death comprised in this summary are the same as those contained in the statistics of 1891.

Total Mortality. — The total reported mortality for the nine years 1883–91 is represented in the accompanying table and diagram, and is made up from 214,593 deaths, the weekly average being 4,127. (See diagram on page 721.)

The special point worthy of notice in this table is the marked increase in the mortality in January, which is due to the epidemic of influenza in January, 1890, and does not appear in a similar table made up for the years preceding 1890.

The second increase in mortality, in March and April, is due very largely to the increased prevalence of acute lung diseases in these months. The mortality curve then descends with considerable uniformity to the end of June, which is usually in New England the month of least mortality.

A very rapid rise then occurs in July, mainly due to the diarrhœal diseases, culminating about August 1, and then descends more gradually till October, when it remains nearly stationary, with a slight rise in December.

The least number of total deaths for the nine years (3,438) occurred in the last week in June, and the greatest number (5,552) occurred in the first week of August.

Deaths of Children under Five Years of Age. — The curve of mortality representing the deaths of children under five years coincides quite closely with the curve of total mortality. The chief exception is the absence of the increase in January, which was due to the influenza of 1890, and which fell with

much greater severity upon the adult than upon the infant population.

The total number of reported deaths of this class was 74,804, and the weekly average 1,439. The greatest number in any one week (3,025) occurred in the thirty-first week (last days of July and first days of August), and the least number (986) in the forty-seventh week (middle of November).

TOTAL DEATHS.—*Deaths under Five Years, and Deaths from Consumption and Acute Lung Diseases for Each Week in the Year (1883–91).*

		Total Deaths.	Deaths Under 5.	Consumption.	Acute Lung Diseases.
First week,		4,175	1,201	664	752
Second week,	Jan.	4,242	1,189	640	789
Third week,		4,421	1,232	680	859
Fourth week,		4,220	1,197	548	715
Fifth week,		4,016	1,162	583	638
Sixth week,	Feb.	3,917	1,231	601	596
Seventh week,		3,998	1,182	598	700
Eighth week,		4,084	1,228	597	653
Ninth week,		4,106	1,261	601	683
Tenth week,		4,147	1,246	609	678
Eleventh week,	March.	4,307	1,257	637	746
Twelfth week,		4,303	1,315	665	741
Thirteenth week,		4,349	1,321	680	783
Fourteenth week,		4,219	1,297	644	668
Fifteenth week,	April.	4,255	1,229	629	702
Sixteenth week,		4,233	1,227	603	796
Seventeenth week,		4,004	1,238	602	660
Eighteenth week,		3,925	1,138	586	600
Nineteenth week,	May.	3,962	1,129	586	593
Twentieth week,		3,956	1,112	613	587
Twenty-first week,		3,854	1,196	599	521
Twenty-second week,		3,662	1,038	588	489
Twenty-third week,		3,634	1,035	577	373
Twenty-fourth week,	June.	3,461	994	584	344
Twenty-fifth week,		3,541	1,104	550	318
Twenty-sixth week,		3,438	1,168	518	303
Twenty-seventh week,		3,747	1,614	497	222
Twenty-eighth week,	July.	4,399	2,096	528	205
Twenty-ninth week,		4,746	2,260	506	240
Thirtieth week,		5,479	2,918	565	183
Thirty-first week,		5,552	3,025	576	195
Thirty-second week,	Aug.	5,185	2,685	570	172
Thirty-third week,		5,212	2,530	568	166
Thirty-fourth week,		4,764	2,163	572	147
Thirty-fifth week,		4,514	2,053	556	197
Thirty-sixth week,		4,447	1,972	554	204
Thirty-seventh week,	Sept.	4,376	1,959	557	206
Thirty-eighth week,		4,230	1,741	564	230
Thirty-ninth week,		4,130	1,678	546	271

TOTAL DEATHS.—*Deaths under Five Years, and Deaths from Consumption and Acute Lung Diseases, etc.*—Concluded.

		Total Deaths.	Deaths Under 5.	Consumption.	Acute Lung Diseases.
Fortieth week,	Oct.	3,936	1,511	535	297
Forty-first week,	Oct.	3,955	1,411	552	304
Forty-second week,	Oct.	3,864	1,211	557	299
Forty-third week,	Oct.	3,758	1,191	539	342
Forty-fourth week,	Nov.	3,563	1,090	554	350
Forty-fifth week,	Nov.	3,733	1,115	549	426
Forty-sixth week,	Nov.	3,710	1,086	564	466
Forty-seventh week,	Nov.	3,564	986	538	462
Forty-eighth week,	Dec.	3,698	1,039	543	490
Forty-ninth week,	Dec.	3,773	1,060	544	499
Fiftieth week,	Dec.	3,871	1,149	561	560
Fifty-first week,	Dec.	3,821	1,125	535	558
Fifty-second week,	Dec.	4,137	1,209	589	721
Total,		214,593	74,804	30,101	24,699
Weekly average,		4,127	1,439	579	475

Consumption.—The total number of reported deaths from consumption for the nine years 1883–91 was 30,101, and the average number for each week was 579. The greatest number in any week for the nine successive years was 680, in the third week of January, and also in the last week of March; and the least number was 497, in the first week of July.

The mortality from this disease appears to have been perceptibly influenced by the epidemic of influenza, which manifested its destructive effect in the last week of December and the first three weeks of January. This excess in winter is, however, balanced by a corresponding decrease in midsummer, which apparently shows that the mortality from consumption, which usually maintains a comparatively uniform rate throughout the year, was hastened by the influenza, so that many deaths which would otherwise have occurred in midsummer were transferred to the preceding midwinter.

The excess of March and April may be considered as a normal excess for these months for the region of Massachusetts.

For the last five months of the year the death rate from this cause continues with comparative uniformity. This diagram may be compared with that which represents the mortality

from the same cause for the six years, 1883–88, on page 239 of the twentieth annual report of the Board, for 1888, in which the mortality appears to be much more uniform from week to week than it was when the two influenza years were included.

The mortality from consumption for the first half of the year constituted 52.5 per cent. of the whole, and that of the last half 47.5 per cent.

Acute Lung Diseases.—The total reported mortality from this group of diseases for the nine years, 1883–91, was 24,699, and the weekly average 475.

The greatest number of deaths in a week for the period of years was 859, in the third week of January, and the least number 147, in the third week of August.

This group of diseases appears to have been influenced by the epidemics of influenza in a similar manner with consumption, and there is, in consequence, a marked increase shown in the mortality from these causes in the last week of December and the first three weeks of January, which does not appear in the summary presented for the six years, 1883–88, published in the twentieth annual report, page 241. From the climax in March there is a rapid decline in the mortality rate until August, and then an increase with somewhat less rapidity until midwinter. The number of deaths from this group of causes in the first half of the year was 16,287, or 66 per cent. of the whole number, and that of the last half was 8,412, or 34 per cent.

Deaths from Typhoid Fever, Diarrhœal Diseases, Measles and Scarlet-fever for Each Week in the Year (1883–91).

		Typhoid Fever.	Diarrhœal Diseases.	Scarlet-fever.	Measles.
First week,	Jan.	79	65	58	24
Second week,		61	47	72	19
Third week,		71	48	68	12
Fourth week,		59	59	56	12
Fifth week,	Feb.	50	54	59	23
Sixth week,		65	45	49	20
Seventh week,		56	47	51	15
Eighth week,		64	37	44	21

Deaths from Typhoid Fever, Diarrhœal Diseases, Measles and Scarlet-fever, etc. — Concluded.

		Typhoid Fever.	Diarrhœal Diseases.	Scarlet-fever.	Measles.
Ninth week,		61	43	51	24
Tenth week,		54	52	55	16
Eleventh week,	March.	59	61	58	20
Twelfth week,		46	55	52	33
Thirteenth week,		57	51	55	28
Fourteenth week,		56	50	60	27
Fifteenth week,	April.	61	64	51	29
Sixteenth week,		51	48	50	39
Seventeenth week,		57	52	58	30
Eighteenth week,		47	70	53	32
Nineteenth week,	May.	47	54	55	35
Twentieth week,		35	57	60	46
Twenty-first week,		48	66	60	45
Twenty-second week,		43	63	58	45
Twenty-third week,		47	80	40	48
Twenty-fourth week,	June.	29	82	38	50
Twenty-fifth week,		44	159	32	40
Twenty-sixth week,		38	258	30	34
Twenty-seventh week,		40	492	26	29
Twenty-eighth week,	July.	39	995	24	24
Twenty-ninth week,		39	1,284	21	18
Thirtieth week,		65	1,842	23	15
Thirty-first week,		73	1,763	23	8
Thirty-second week,	Aug.	68	1,548	33	12
Thirty-third week,		107	1,363	21	11
Thirty-fourth week,		110	1,177	29	7
Thirty-fifth week,		125	1,086	29	5
Thirty-sixth week,		133	913	35	4
Thirty-seventh week,	Sept.	159	823	31	7
Thirty-eighth week,		157	680	36	5
Thirty-ninth week,		174	540	38	7
Fortieth week,		183	423	34	5
Forty-first week,	Oct.	137	336	36	6
Forty-second week,		153	225	37	4
Forty-third week,		157	187	47	6
Forty-fourth week,		138	150	50	7
Forty-fifth week,	Nov.	112	99	57	3
Forty-sixth week,		114	83	61	13
Forty-seventh week,		110	69	54	12
Forty-eighth week,		101	71	51	6
Forty-ninth week,		93	52	47	10
Fiftieth week,	Dec.	88	51	64	4
Fifty-first week,		81	43	74	11
Fifty-second week,		97	66	53	15
Total,		4,238	18,128	2,407	1,021
Weekly average,		81	349	46	20

Typhoid Fever. — The whole number of deaths from typhoid fever for the period of nine years was 4,238, and the weekly average was 81. The greatest number (183) occurred in the first week of October, and the least number (29) in the second week of June

The mortality from typhoid fever diminishes gradually from an average rate in January to its minimum in June and July, then increases rapidly to a maximum in September and October, and then diminishes with nearly the same rate to the close of the year. The prevalence of the disease in several cities having polluted water supplies throughout the winter has perceptibly influenced the curve of mortality, which would otherwise have maintained a lower rate from December until spring.

The number of deaths in the first half of the year was 1,385, or 32.7 per cent., and the number which occurred in the last half was 2,853, or 67.3 per cent.

Diarrhœal Diseases. — This group of diseases includes the deaths ascribed to diarrhœa, dysentery, cholera morbus and cholera infantum. The whole number from these causes, for the period of nine years, was 18,128, and the weekly average was 349.

The greatest number of deaths from this group of causes (1,842) occurred in the last week of July, and the least number (37) in the last week of February.

A tolerably uniform and low rate of mortality is maintained from January to June, and then a very sharp and rapid rise through the month of July to its maximum, with a somewhat less rapid decline to a minimum in November and December.

The number of deaths from diarrhœal diseases in the first half of the year was 1,767, or 9.8 per cent., and those in the last half were 16,361, or 90.2 per cent.

Scarlet-fever. — The whole number of reported deaths from this cause for the period of nine years was 2,407, and the weekly average was 46.

The greatest number (74) occurred in the third week of December, and the least number (21) in the third weeks of July and August.

The mortality continued at quite a uniform rate from the first

week of November till the last of May, when there was quite an abrupt falling off to a minimum in July and August. The mortality of the first half of the year was 1,373, or 57 per cent., and that of the last half was 1,034, or 43 per cent.

Measles.—The whole number of reported deaths from this cause for the period of nine years was 1,021, and the weekly average 20.

The greatest number (50) occurred in the second week in June, and the least number (3) in the first week of November.

The mortality from measles increased gradually from an average in January till June, when it declined more rapidly, and maintained a fairly uniform but low rate throughout the last half of the year.

The deaths during the first half of the year were 767, or 75 per cent., and those of the last half were 254, or 25 per cent. of the whole.

Diphtheria and Croup.—The reported mortality from these causes during the nine years was 9,313, and the weekly average was 179.

The greatest number of reported deaths (279) occurred in the second week of December, and the least number (81) occurred in the second week in August.

The mortality rate declined gradually from January to July, and then increased more rapidly till November, when it remained stationary for about eleven weeks, at its maximum, from the last half of October until the second week of January.

The deaths of the first half of the year (4,749) constituted 51 per cent. of the total mortality from the same causes, and those of the last half were 4,564, or 49 per cent.

Whooping-cough.—The total reported mortality from this cause for the period of nine years was 1,276, and the weekly average was 24.

The greatest number of reported deaths (59) occurred in the second week of August, and the least number (8) in the last week of November.

The mortality rate continued with a tolerably uniform rate throughout the first half of the year, increased gradually in

July, rose suddenly to a maximum in August, and then declined gradually to a minimum in November.

The reported deaths in the first half of the year (572) constituted 45 per cent., and those of the last half (704) were 55 per cent. of the total reported mortality from this cause.

Deaths from Diphtheria and Croup, Whooping-cough, Malarial Fever, Puerperal Fever and Erysipelas for Each Week (1883-91).

		Diphtheria and Croup.	Whooping-cough.	Malarial Fever.	Puerperal Fever.	Erysipelas.
First week,		271	20	5	5	13
Second week,	Jan.	229	21	2	11	14
Third week,		230	31	2	14	23
Fourth week,		222	26	-	17	26
Fifth week,		214	28	2	14	19
Sixth week,	Feb.	218	25	2	19	21
Seventh week,		218	22	4	12	19
Eighth week,		201	23	2	13	18
Ninth week,		198	20	-	15	12
Tenth week,		175	21	-	13	17
Eleventh week,	March.	168	33	1	11	20
Twelfth week,		169	26	2	12	18
Thirteenth week,		162	22	1	9	17
Fourteenth week,		150	18	4	13	14
Fifteenth week,	April.	173	26	2	23	27
Sixteenth week,		171	23	2	17	19
Seventeenth week,		150	13	4	11	20
Eighteenth week,		156	14	1	10	21
Nineteenth week,	May.	184	14	1	10	21
Twentieth week,		167	16	3	12	21
Twenty-first week,		163	18	-	11	19
Twenty-second week,		179	24	2	13	14
Twenty-third week,		146	24	-	8	15
Twenty-fourth week,	June.	146	17	2	10	13
Twenty-fifth week,		139	23	2	11	8
Twenty-sixth week,		150	24	2	7	8
Twenty-seventh week,		141	27	4	9	5
Twenty-eighth week,	July.	108	28	2	7	5
Twenty-ninth week,		105	31	3	6	7
Thirtieth week,		115	38	1	10	7
Thirty-first week,		125	36	6	6	5
Thirty-second week,	Aug.	81	59	1	4	5
Thirty-third week,		110	53	4	9	6
Thirty-fourth week,		115	46	4	8	5
Thirty-fifth week,		142	39	6	8	5
Thirty-sixth week,	Sept.	108	37	3	3	2
Thirty-seventh week,		126	34	3	7	2
Thirty-eighth week,		134	30	3	5	4
Thirty-ninth week,		154	27	4	6	5
Fortieth week,		171	23	2	4	2
Forty-first week,	Oct.	185	24	3	8	3
Forty-second week,		215	22	2	5	6
Forty-third week,		239	17	-	6	6

Deaths from Diphtheria and Croup, Whooping-cough, Malarial Fever, Puerperal Fever and Erysipelas, etc. — Concluded.

		Diphtheria and Croup.	Whooping-cough.	Malarial Fever.	Puerperal Fever.	Erysipelas.
Forty-fourth week, . .	Nov.	230	14	1	6	7
Forty-fifth week, . .	Nov.	252	17	1	8	6
Forty-sixth week, . .	Nov.	222	11	2	6	8
Forty-seventh week, .	Nov.	249	13	1	8	8
Forty-eighth week, . .	Dec.	235	8	3	10	7
Forty-ninth week, . .	Dec.	234	16	1	6	8
Fiftieth week, . . .	Dec.	279	10	1	9	10
Fifty-first week, . .	Dec.	235	24	1	5	10
Fifty-second week, . .	Dec.	254	20	1	3	16
Total, ...		9,313	1,276	111	493	617
Weekly average, . .		179	24	2	9.5	12

Malarial Fever. — The deaths reported from this cause were 111, and the average weekly mortality was 2. These numbers are scarcely large enough to warrant any just conclusions as to the seasonal prevalence of the disease, which, fortunately, is not very fatal, and does not, therefore, manifest itself very prominently in these statistics.

The reported deaths from malarial fever for the first half of the year were 48, or 43 per cent. of the whole, and those of the last half were 63, or 57 per cent.

Puerperal Fever. — The total number of reported deaths from this cause for the period of nine years was 493, and the weekly average was 9.5.

The mortality was maintained at a comparatively high rate from January to April, and then declined gradually to the close of the year.

The number of deaths in the first half of the year of this period was 321, or 65 per cent., and those of the last half were 172, or 35 per cent.

Erysipelas. — The total number of deaths reported from this cause for the period of nine years was 617, and the weekly average 12. Of this number, 457, or 74 per cent., occurred in the first half of the year, and 160, or 26 per cent., occurred in the last half.

The mortality rate from erysipelas continued high through-

out the first part of the year, from January until the middle of May, when it rapidly declined to midsummer, continuing through the last half of the year at a comparatively low rate, with a slight rise in November and December.

Generally speaking, the curve of mortality from this cause followed a similar course with that of puerperal fever, but with a greater contrast between the mortality of the first and last half of the year, and with a more rapid decline during the summer.

Small-pox. — The total number of deaths from this cause (46) during the nine years was so small as to be of but little value for the purpose of illustrating seasonal prevalence.

The Influenza Epidemics of 1889–90 and 1891–92.

The accompanying table and diagram illustrate the reported mortality from acute lung diseases during the prevalence of the two epidemics of influenza in 1889–90 and in 1891–92.

The former epidemic manifested itself by a sudden rise in the mortality from these diseases, beginning about the 20th of December and culminating in the middle week of January, and then falling off quite suddenly in February to about the usual rate for these diseases.

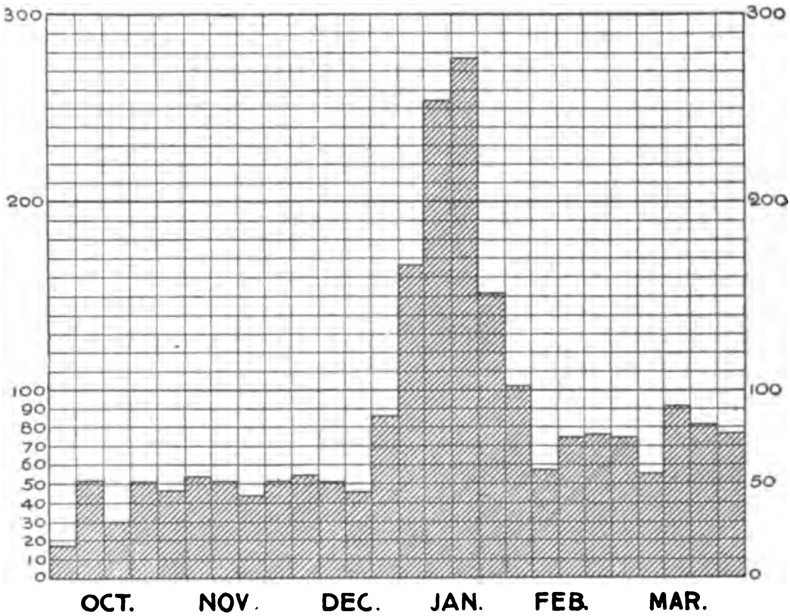
The second epidemic, two years later, began with a more gradual rise in October and November and then increased much more sharply in December, continued for nearly three weeks at its maximum in January, and declined nearly as sharply as in the previous epidemic two years before: —

Acute Lung Diseases (Six Months).

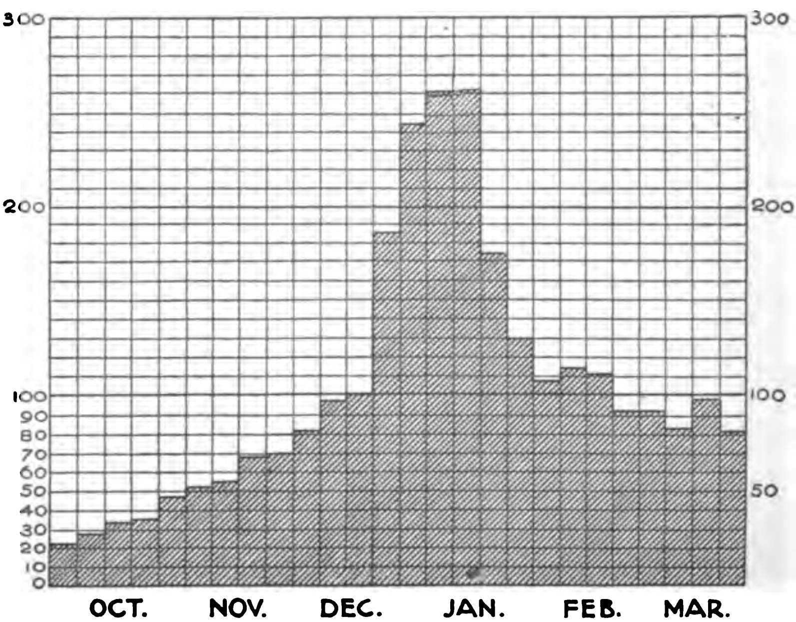
Epidemic of 1889-90.		Epidemic of 1891-92.	
Week ending Oct. 5, 1889, .	17	Week ending Oct. 3, 1891, .	22
" " " 12, 1889, .	51	" " " 10, 1891, .	28
" " " 19, 1889, .	30	" " " 17, 1891, .	34
" " " 26, 1889, .	51	" " " 24, 1891, .	35
" " Nov. 2, 1889, .	46	" " " 31, 1891, .	47
" " " 9, 1889, .	54	" " Nov. 7, 1891, .	52
" " " 16, 1889, .	51	" " " 14, 1891, .	54
" " " 23, 1889, .	44	" " " 21, 1891, .	69
" " " 30, 1889, .	51	" " " 28, 1891, .	70
" " Dec. 7, 1889, .	55	" " Dec. 5, 1891, .	82
" " " 14, 1889, .	51	" " " 12, 1891, .	97
" " " 21, 1889, .	46	" " " 19, 1891, .	100
" " " 28, 1889, .	86	" " " 26, 1891, .	185
" " Jan. 4, 1890, .	167	" " Jan. 2, 1892, .	244
" " " 11, 1890, .	255	" " " 9, 1892, .	260
" " " 18, 1890, .	277	" " " 16, 1892, .	263
" " " 25, 1890, .	151	" " " 23, 1892, .	174
" " Feb. 1, 1890, .	102	" " " 30, 1892, .	130
" " " 8, 1890, .	57	" " Feb. 6, 1892, .	107
" " " 15, 1890, .	75	" " " 13, 1892, .	113
" " " 22, 1890, .	77	" " " 20, 1892, .	110
" " March 1, 1890, .	75	" " " 27, 1892, .	92
" " " 8, 1890, .	56	" " March 5, 1892, .	92
" " " 15, 1890, .	92	" " " 12, 1892, .	83
" " " 22, 1890, .	81	" " " 19, 1892, .	98
" " " 29, 1890, .	77	" " " 26, 1892, .	81

ACUTE LUNG DISEASES

EPIDEMIC OF 1889-90.



EPIDEMIC OF 1891-92.



Mortality Rates of Cities.

The following tables contain the mortality rates for each week of those cities which have sent returns to the State Board of Health during 1891.

These rates are calculated from the estimated population for 1891, the method of estimating the population being that which is usually employed. This method is based upon the supposition that the annual rate of increase which prevailed between 1890 and the preceding census was also maintained to the middle of the year 1891. This method is the same as is employed by the registrar-general of England, and is the most reasonable mode. The cause which is most liable to act as a disturbing element in this method is the difference in the rate of immigration and emigration in successive years.

Reported Mortality Rates of Cities for 1891.

1891. Week Ending—	Boston.	Worcester.	Lowell.	1891. Week Ending—	Boston.	Worcester.	Lowell.
Jan. 3,	23.08	14.08	20.77	July 4,	16.19	8.21	24.66
10,	24.01	18.78	25.31	11,	20.38	12.32	33.75
17,	25.71	13.50	21.42	18,	23.44	22.30	35.05
24,	22.08	10.56	20.12	25,	31.82	23.48	25.96
31,	20.50	17.26	26.61	Aug. 1,	31.25	15.84	31.16
Feb. 7,	19.02	19.95	31.81	8,	23.77	20.54	31.16
14,	17.66	12.91	29.21	15,	29.33	24.06	32.46
21,	20.83	11.74	19.47	22,	25.59	17.26	24.66
28,	21.40	12.91	31.81	29,	22.99	25.82	27.91
March 7,	22.76	16.43	27.26	Sept. 5,	21.29	17.26	23.37
14,	21.85	14.08	30.51	12,	22.65	17.02	27.26
21,	19.25	10.56	29.21	19,	20.61	16.43	19.47
28,	22.10	12.91	23.37	26,	23.21	17.26	33.75
April 4,	22.22	15.84	22.07	Oct. 3,	22.76	17.61	20.12
11,	23.08	17.02	27.26	10,	19.25	18.78	25.31
18,	26.61	14.08	20.12	17,	24.23	17.61	22.07
25,	21.29	16.43	25.31	24,	21.17	16.43	19.47
May 2,	27.29	10.56	19.47	31,	20.50	14.08	25.96
9,	21.29	18.78	21.42	Nov. 7,	20.95	18.19	20.12
16,	23.77	20.54	25.96	14,	20.27	14.08	18.82
23,	24.57	12.32	25.31	21,	20.61	14.08	11.68
30,	21.85	19.95	22.71	28,	20.04	19.95	18.17
June 6,	20.16	9.39	21.42	Dec. 5,	22.76	18.78	22.07
13,	19.48	10.56	19.47	12,	24.12	17.26	22.07
20,	23.78	15.84	24.02	19,	26.04	19.95	13.63
27,	16.98	9.39	18.17	26,	33.07	28.17	22.72

Estimated population of Boston (1891),	459,062
Total deaths,	10,572
Estimated death-rate,	23.02
Estimated population of Worcester (1891),	88,484
Total deaths,	1,700
Estimated death-rate,	19.21
Estimated population of Lowell (1891),	80,076
Total deaths,	1,996
Estimated death-rate,	24.92

Reported Mortality Rates of Cities for 1891 — Continued.

1891. Week Ending —	Fall River.	Cambridge.	Lynn.	1891. Week Ending —	Fall River.	Cambridge.	Lynn.
Jan. 3, . . .	17.93	10.06	13.21	July 4, . . .	21.92	16.52	10.70
10, . . .	19.26	25.09	8.03	11, . . .	40.53	25.16	9.81
17, . . .	17.27	10.78	13.21	18, . . .	35.21	28.03	13.21
24, . . .	15.28	17.25	13.21	25, . . .	36.54	30.19	11.59
31, . . .	13.94	16.53	13.21	Aug. 1, . . .	38.53	35.22	24.97
Feb. 7, . . .	23.91	17.25	16.06	8, . . .	31.22	16.53	23.29
14, . . .	15.94	13.65	14.28	15, . . .	34.54	23.72	25.86
21, . . .	15.28	17.25	11.59	22, . . .	27.24	20.12	20.51
28, . . .	13.94	23.72	14.96	29, . . .	29.90	11.50	10.70
March 7, . . .	16.61	17.72	12.48	Sept. 5, . . .	25.91	16.53	14.28
14, . . .	21.92	18.43	14.96	12, . . .	23.91	19.40	9.81
21, . . .	19.26	21.56	29.43	19, . . .	26.57	19.40	14.28
28, . . .	22.58	12.22	17.84	26, . . .	26.57	14.37	13.21
April 4, . . .	20.59	19.40	11.59	Oct. 3, . . .	23.25	25.09	20.51
11, . . .	17.93	25.87	16.06	10, . . .	29.23	12.93	19.62
18, . . .	31.22	15.81	20.51	17, . . .	26.57	23.00	8.92
25, . . .	34.54	18.43	13.21	24, . . .	21.26	18.43	24.97
May 2, . . .	17.93	17.72	19.62	31, . . .	16.16	15.81	9.81
9, . . .	29.23	14.37	16.94	Nov. 7, . . .	25.24	14.37	9.81
16, . . .	19.93	23.00	16.06	14, . . .	11.95	20.12	14.96
23, . . .	17.27	28.03	18.73	21, . . .	15.28	25.87	21.40
30, . . .	21.92	15.81	16.06	28, . . .	19.93	19.40	20.51
June 6, . . .	17.93	17.97	14.96	Dec. 5, . . .	10.63	12.93	16.06
13, . . .	19.26	7.18	18.73	12, . . .	17.93	17.25	10.70
20, . . .	23.91	18.43	12.48	19, . . .	21.92	15.81	10.70
27, . . .	21.26	12.22	16.06	26, . . .	20.59	17.25	24.97

Estimated population of Fall River, ...	78,268
Total deaths, ...	2,084
Estimated death-rate, ...	26.62
Estimated population of Cambridge, ...	72,336
Total deaths, ...	1,507
Estimated death-rate, ...	20.83
Estimated population of Lynn, ...	58,268
Total deaths, ...	1,049
Estimated death-rate, ...	18.00

Reported Mortality Rates of Cities for 1891 — Continued.

1891. Week Ending —	Lawrence.	Springfield.	New Bedford.	1891. Week Ending —	Lawrence.	Springfield.	New Bedford.
Jan. 3, . . .	25.25	15.96	14.56	July 4, . . .	28.70	15.96	15.78
10, . . .	30.99	17.10	14.56	11, . . .	26.40	14.82	10.92
17, . . .	29.84	22.80	23.06	18, . . .	27.55	25.08	21.85
24, . . .	29.84	29.64	16.99	25, . . .	33.29	31.92	20.63
31, . . .	21.81	13.68	10.92	Aug. 1, . . .	16.07	29.64	33.99
Feb. 7, . . .	19.51	18.24	15.78	8, . . .	29.84	22.80	30.35
14, . . .	25.25	18.24	14.56	15, . . .	26.40	17.10	42.55
21, . . .	27.55	19.38	18.21	22, . . .	26.40	13.68	35.20
28, . . .	17.22	20.52	25.49	29, . . .	25.25	27.36	18.21
March 7, . . .	22.96	10.26	8.49	Sept. 5, . . .	18.36	26.22	26.70
14, . . .	20.66	9.12	10.92	12, . . .	22.96	15.96	18.21
21, . . .	17.22	18.24	20.63	19, . . .	17.22	17.10	40.06
28, . . .	21.81	9.12	33.99	26, . . .	25.25	9.12	26.70
April 4, . . .	25.25	18.24	29.13	Oct. 3, . . .	21.81	26.22	19.42
11, . . .	26.40	17.10	20.75	10, . . .	21.81	19.38	24.28
18, . . .	26.40	12.54	26.70	17, . . .	19.51	12.54	35.20
25, . . .	15.92	12.54	26.70	24, . . .	18.36	10.26	15.78
May 2, . . .	20.66	12.54	20.63	31, . . .	18.36	17.10	18.21
9, . . .	22.96	19.38	15.78	Nov. 7, . . .	17.22	19.38	15.78
16, . . .	21.81	12.54	27.92	14, . . .	19.51	18.24	25.49
23, . . .	18.36	19.38	13.35	21, . . .	25.25	12.54	7.28
30, . . .	27.55	12.54	16.99	28, . . .	25.25	18.24	19.42
June 6, . . .	18.36	19.38	14.56	Dec. 5, . . .	20.66	22.80	20.75
13, . . .	21.81	10.26	16.99	12, . . .	24.10	19.38	35.20
20, . . .	20.66	18.24	18.21	19, . . .	41.32	21.66	33.99
27, . . .	15.92	14.82	12.14	26, . . .	53.95	37.62	40.06

Estimated population of Lawrence, ...	45,281
Total deaths, ...	1,194
Estimated death-rate, ...	26.36
Estimated population of Springfield, ...	45,615
Total deaths, ...	927
Estimated death-rate, ...	20.32
Estimated population of New Bedford, ...	42,840
Total deaths, ...	1,046
Estimated death-rate, ...	24.41

Reported Mortality Rates of Cities for 1891 — Continued.

1891. Week Ending —	Salem.	Chelsea.	Haverhill.	1891. Week Ending —	Salem.	Chelsea.	Haverhill.
Jan. 3, . . .	13.34	38.05	14.47	July 4, . . .	13.34	23.55	16.28
10, . . .	10.00	16.30	16.28	11, . . .	8.34	16.30	19.89
17, . . .	21.68	19.93	16.28	18, . . .	15.01	25.36	36.18
24, . . .	13.34	23.55	12.66	25, . . .	26.68	7.24	21.70
31, . . .	15.01	14.49	14.47	Aug. 1, . . .	36.69	32.61	28.94
Feb. 7, . . .	11.67	16.30	26.32	8, . . .	28.35	32.61	34.37
14, . . .	21.68	23.55	26.32	15, . . .	26.68	23.55	18.09
21, . . .	10.00	16.30	16.28	22, . . .	23.35	16.30	21.70
28, . . .	16.68	19.93	9.04	29, . . .	33.36	25.36	26.32
March 7, . . .	18.34	28.99	27.13	Sept. 5, . . .	23.35	19.93	16.28
14, . . .	21.68	21.74	10.85	12, . . .	15.01	25.36	14.47
21, . . .	18.34	10.87	14.47	19, . . .	28.35	21.74	14.47
28, . . .	13.34	25.36	26.32	26, . . .	20.01	28.99	14.47
April 4, . . .	16.68	18.12	23.51	Oct. 3, . . .	16.68	18.12	14.47
11, . . .	18.34	27.18	14.47	10, . . .	26.68	28.99	18.09
18, . . .	16.68	16.30	14.47	17, . . .	21.68	39.86	7.23
25, . . .	18.31	16.30	12.66	24, . . .	21.68	25.36	14.47
May 2, . . .	25.02	30.80	14.47	31, . . .	15.01	12.68	5.42
9, . . .	20.01	14.49	28.94	Nov. 7, . . .	16.68	19.93	14.47
16, . . .	13.34	21.74	30.75	14, . . .	11.67	32.61	28.94
23, . . .	10.00	23.55	16.28	21, . . .	15.01	36.24	9.04
30, . . .	16.68	9.06	23.51	28, . . .	13.34	23.55	14.47
June 6, . . .	10.00	10.87	14.47	Dec. 5, . . .	16.68	23.55	18.09
13, . . .	15.01	14.49	3.61	12, . . .	10.00	27.18	26.82
20, . . .	25.02	21.74	21.70	19, . . .	16.68	21.74	26.32
27, . . .	15.01	19.93	18.09	26, . . .	25.02	27.18	21.70

Estimated population of Salem,	31,163
Total deaths,	657
Estimated death-rate,	21.08
Estimated population of Chelsea,	28,694
Total deaths,	735
Estimated death-rate,	25.61
Estimated population of Haverhill,	28,738
Total deaths,	581
Estimated death-rate,	20.21

Reported Mortality Rates of Cities for 1891 — Continued.

1891. Week Ending —	Taunton.	Gloucester.	Newton.	1891. Week Ending —	Taunton.	Gloucester.	Newton.
Jan. 3, . . .	10.01	14.37	6.13	July 4, . . .	12.01	4.10	14.30
10, . . .	16.02	18.47	8.17	11, . . .	12.01	6.15	20.44
17, . . .	26.04	14.37	18.39	18, . . .	14.02	14.37	24.48
24, . . .	6.00	4.10	12.26	25, . . .	6.00	6.15	8.17
31, . . .	14.02	16.42	14.30	Aug. 1, . . .	18.02	8.21	10.22
Feb. 7, . . .	8.00	8.21	12.26	8, . . .	20.03	4.10	14.30
14, . . .	18.02	10.26	10.22	15, . . .	22.03	18.47	18.39
21, . . .	8.00	14.37	8.17	22, . . .	24.03	8.21	14.30
28, . . .	10.01	8.21	8.17	29, . . .	12.01	39.00	14.30
March 7, . . .	8.00	10.26	14.30	Sept. 5, . . .	10.01	30.79	18.39
14, . . .	18.02	4.10	10.22	12, . . .	16.02	16.42	22.44
21, . . .	22.03	14.37	22.44	19, . . .	32.04	20.53	16.35
28, . . .	4.00	8.21	22.44	26, . . .	6.00	10.26	10.22
April 4, . . .	14.02	14.37	16.35	Oct. 3, . . .	30.04	12.31	12.26
11, . . .	14.02	14.37	10.22	10, . . .	14.02	14.37	14.30
18, . . .	14.02	12.31	14.30	17, . . .	12.01	16.42	18.39
25, . . .	22.03	22.58	20.44	24, . . .	8.00	18.27	6.13
May 2, . . .	26.04	18.47	14.30	31, . . .	14.02	12.31	16.35
9, . . .	14.02	8.21	12.26	Nov. 7, . . .	14.02	18.27	12.26
16, . . .	12.01	8.21	14.30	14, . . .	24.03	10.26	12.26
23, . . .	18.02	12.31	18.39	21, . . .	6.00	6.15	18.39
30, . . .	12.01	12.31	6.00	28, . . .	20.03	12.31	8.17
June 6, . . .	14.02	10.26	10.22	Dec. 5, . . .	18.02	18.27	18.39
13, . . .	18.02	16.42	4.08	12, . . .	14.02	10.26	10.22
20, . . .	8.00	22.58	6.13	19, . . .	22.03	22.58	18.39
27, . . .	4.00	16.42	8.17	26, . . .	22.03	12.31	22.44

Estimated population of Taunton, ... 25,956
Total deaths, ... 511
Estimated death-rate, ... 19.69
Estimated population of Gloucester, ... 25,328
Total deaths, ... 440
Estimated death-rate, ... 17.37
Estimated population of Newton, ... 25,438
Total deaths, ... 373
Estimated death-rate, ... 14.66

Reported Mortality Rates of Cities for 1891 — Continued.

1891. Week Ending —	Malden.	Fitchburg.	Waltham.	1891. Week Ending —	Malden.	Fitchburg.	Waltham.
Jan. 3, . . .	12.42	6.57	15.74	July 4, . . .	12.42	4.38	15.74
10, . . .	10.35	15.33	7.87	11, . . .	6.21	10.95	13.12
17, . . .	6.21	13.14	13.12	18, . . .	12.42	21.90	13.12
24, . . .	8.28	19.71	10.49	25, . . .	12.42	10.95	7.87
31, . . .	8.28	8.76	10.49	Aug. 1, . . .	26.88	13.14	15.74
Feb. 7, . . .	4.14	8.76	18.36	8, . . .	26.88	19.71	18.36
14, . . .	14.49	10.95	10.49	15, . . .	10.35	30.66	18.36
21, . . .	16.56	17.52	18.36	22, . . .	24.81	41.61	5.24
28, . . .	14.49	8.76	15.74	29, . . .	26.88	24.09	26.24
March 7, . . .	14.49	17.52	20.99	Sept. 5, . . .	8.28	19.71	15.74
14, . . .	18.63	19.71	10.49	12, . . .	12.42	19.71	23.61
21, . . .	16.56	17.52	20.99	19, . . .	16.56	10.95	13.12
28, . . .	12.42	19.71	13.12	26, . . .	12.42	19.71	13.12
April 4, . . .	16.56	10.95	20.99	Oct. 3, . . .	10.35	15.33	10.49
11, . . .	6.21	17.52	15.74	10, . . .	24.81	37.23	28.86
18, . . .	14.49	8.76	10.49	17, . . .	16.56	10.95	23.61
25, . . .	12.42	15.33	7.87	24, . . .	6.21	17.52	13.12
May 2, . . .	16.56	24.09	10.49	31, . . .	10.35	10.95	15.74
9, . . .	14.49	15.33	26.24	Nov. 7, . . .	14.49	8.76	10.49
16, . . .	10.35	21.90	18.36	14, . . .	16.56	13.14	10.49
23, . . .	14.49	13.14	7.87	21, . . .	24.81	19.71	15.74
30, . . .	8.28	6.57	10.49	28, . . .	16.56	13.14	18.36
June 6, . . .	20.68	6.57	10.49	Dec. 5, . . .	12.42	10.95	20.99
13, . . .	12.42	8.76	10.49	12, . . .	12.42	26.28	15.74
20, . . .	20 68	10.95	10.49	19, . . .	22.74	10.95	20.99
27, . . .	14.49	6.57	13.12	26, . . .	26.88	19.71	23.61

Estimated population of Malden,	25,141
Total deaths,	427
Estimated death-rate,	16.98
Estimated population of Fitchburg,	23,740
Total deaths,	437
Estimated death-rate,	18.40
Estimated population of Waltham,	19,812
Total deaths,	327
Estimated death-rate,	16.50

Reported Mortality Rates of Cities for 1891 — Concluded.

1891. Week Ending —	Pittsfield.	Quincy.	Newburyport.	1891. Week Ending —	Pittsfield.	Quincy.	Newburyport.
Jan. 3, . . .	17.53	23.50	22.20	July 4, . . .	11.69	14.69	22.20
10, . . .	14.61	20.56	26.01	11, . . .	8.76	2.93	7.43
17, . . .	43.85	23.50	29.73	18, . . .	8.76	17.62	18.58
24, . . .	8.76	20.56	14.86	25, . . .	8.76	17.62	11.15
31, . . .	14.61	14.69	33.45	Aug. 1, . . .	8.76	47.01	33.45
Feb. 7, . . .	5.84	20.56	29.73	8, . . .	14.61	20.56	18.58
14, . . .	17.53	14.69	22.20	15, . . .	14.61	22.44	18.58
21, . . .	17.53	14.69	18.58	22, . . .	17.53	17.62	37.17
28, . . .	17.53	11.75	11.15	29, . . .	23.38	5.87	33.45
March 7, . . .	5.84	17.62	7.43	Sept. 5, . . .	14.61	20.56	29.73
14, . . .	2.92	11.75	18.58	12, . . .	14.61	7.81	11.15
21, . . .	14.61	23.50	11.15	19, . . .	11.69	14.69	33.45
28, . . .	8.76	23.50	22.20	26, . . .	8.76	14.69	22.20
April 4, . . .	11.69	5.87	18.58	Oct. 3, . . .	11.69	17.62	14.86
11, . . .	8.76	11.75	7.43	10, . . .	8.76	7.81	33.45
18, . . .	20.46	17.62	26.01	17, . . .	11.69	14.69	18.58
25, . . .	8.76	7.81	26.01	24, . . .	8.76	29.38	7.43
May 2, . . .	8.76	11.75	18.58	31, . . .	11.69	17.62	29.73
9, . . .	11.69	11.75	7.43	Nov. 7, . . .	14.61	14.69	26.01
16, . . .	8.76	14.69	14.86	14, . . .	14.61	5.87	14.86
23, . . .	14.61	17.62	11.15	21, . . .	17.53	7.81	26.01
30, . . .	5.84	2.93	26.01	28, . . .	14.61	2.93	40.88
June 6, . . .	8.76	5.87	26.01	Dec. 5, . . .	17.53	20.56	26.01
13, . . .	5.84	17.62	33.45	12, . . .	5.84	11.75	22.20
20, . . .	43.84	20.56	7.43	19, . . .	14.61	5.87	14.86
27, . . .	11.69	17.62	18.58	26, . . .	11.69	20.56	18.58

Estimated population of Pittsfield,	17,787
Total deaths,	348
Estimated death-rate,	19.56
Estimated population of Quincy,	17,696
Total deaths,	320
Estimated death-rate,	18.08
Estimated population of Newburyport,	13,988
Total deaths,	394
Estimated death-rate,	28.16

ON THE

GEOGRAPHICAL DISTRIBUTION

OF CERTAIN

CAUSES OF DEATH IN MASSACHUSETTS.

By Samuel W. Abbott, M.D.,

Secretary of the Board.

ON THE GEOGRAPHICAL DISTRIBUTION OF CERTAIN CAUSES OF DEATH IN MASSACHUSETTS.

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The following statistical inquiry has been undertaken with the object of studying, upon the broadest basis available, the question whether certain diseases or causes of death are influenced by geographical position, within the limits of the State of Massachusetts. At the same time other circumstances and conditions have been made the subject of observation, such as sex, age, seasons of the year, density of population and freedom of intercommunication.

The period of time selected for observation is the twenty years from 1871 to 1890 inclusive, this being the longest period during which such facts could readily be studied without an excessive increase in the amount of clerical labor involved.

The diseases selected for observation are *measles*, *scarlet-fever*, *diphtheria and croup* (considered together), *small-pox*, *typhoid fever*, *cholera infantum*, *phthisis and pneumonia*. These destructive diseases, part of which are well known as preventable, were the cause of forty per cent. of the deaths in the State during the period in question.

The sources of information are mainly the registration reports of the State which cover this period.

Dr. Farr stated, in his first report to the Registrar-General of England, that "the registration of the diseases of the several districts will furnish medical men with a series of valuable

remedial agents. It will designate the localities where disease is most rife, and where there is the most tendency to particular classes of sickness and infirmity."

The value of the following study consists mainly in the light which may possibly be thrown upon the study of the causes of disease. A thorough knowledge of the natural history of infectious diseases, including their etiology, is essential to an understanding of the methods to be adopted for their prevention.

Dr. Haviland says upon this point: "It is for this reason that I look upon the investigation connected with the geographical distribution of disease as essential to a practical knowledge of preventive medicine; for it involves the study of the physical, geological, meteorological and other natural and social characters of the country or district, the diseases of which are the subject of inquiry."

Allowance must be made in the following paper for the fact that all medical statistics based upon the returns of causes of death are only as trustworthy as medical diagnosis can make them. The following table, from the registration report of 1890, shows, however, that a progressive improvement has taken place in this direction, and that the number of deaths from "unknown or unspecified causes" has gradually diminished in the past twenty years.

Deaths from Unknown or Unspecified Causes, and Percentages, 1871-1890 (20 Years).

YEARS.	Total Deaths.	Deaths from Unknown Causes.	Percentage.	YEARS.	Total Deaths.	Deaths from Unknown Causes.	Percentage.
1871,	27,948	1,290	4.62	1881,	36,458	665	1.82
1872,	35,019	1,457	4.16	1882,	36,785	590	1.60
1873,	33,912	1,302	3.84	1883,	37,748	680	1.80
1874,	31,887	1,138	3.57	1884,	36,990	535	1.45
1875,	34,978	1,017	2.91	1885,	38,094	500	1.31
1876,	33,186	999	3.01	1886,	37,244	452	1.21
1877,	31,342	910	2.90	1887,	40,763	498	1.22
1878,	31,303	837	2.67	1888,	42,097	538	1.28
1879,	31,801	775	2.44	1889,	41,777	490	1.17
1880,	35,292	745	2.11	1890,	43,528	516	1.19
Average (1871-1880),			3.21	Average (1881-1890),			1.37

Another point which should be borne in mind is the danger of making deductions from small populations, in which a very slight increase or decrease in the number of deaths from any disease has a violent effect upon the mortality rate of such population. In the study of small-pox, for example, the difference between one and two deaths from this cause in any one of the small towns changes its position from a rank below the average to an excessively high position, and far above the average. Hence the principal conclusions in this paper will be taken from large groupings, and not from the extremely small populations of the towns in rural districts.

The compiler recognizes that any statistician may have personal and peculiar views in regard to subjects which he may be called upon to treat, which may bias his mind in the interpretation of statistics whenever doubt arises. The primary requisite, as Dr. Longstaff says, in the treatment of statistics, is a logical mind and a sound logical training, and, secondly, a good general knowledge of his subject.

The number of municipalities having a city government at the beginning of the period (1871–90) was 14, and the number having such form of government at the close of the period was 28. Those having town governments at the beginning of the period were 322, and at the close 318.

A few changes have been made in the dividing lines of towns, for which due allowance has been made, where the changes included territory containing a considerable number of inhabitants; and a few new towns have been incorporated.

Arbitrary methods must necessarily be taken for expressing the ratios of mortality upon the map, and in many instances towns occupying an area of fifty or even one hundred square miles of surface may have a rural population of one, two or three thousand inhabitants, occupying but a small portion of this area.

The population used as a basis for calculating the ratios of mortality is that of 1880 (U. S. census), which is taken as an average of the whole period of twenty years. This would be sufficiently correct for all towns in which the rate of increase was uniform for the whole period of twenty years.

For a considerable number of the cities and towns, however, the increase in the second decade was much greater than that

of the first. For these towns, about one-fourth of the whole number, a re-estimate was made and an average taken of the population by five census enumerations, 1870, '75, '80, '85 and '90. In many of the farming towns the population was quite stationary and in some there was a decrease.

In considering the different parts of the State with reference to the comparative prevalence of different diseases, the county has been selected as a large sanitary district. It is evident, however, that such divisions have but little significance for the purpose of sanitary study.

For example, Franklin, Hampshire and Hampden counties have quite similar characteristics in their equal distance from the sea, in forming the principal drainage basin of that part of the Connecticut River which traverses the State, and in other characteristics. They might therefore be treated as one group.

For the purpose of making a more intelligent classification I have therefore classified the towns into two general divisions of manufacturing or densely settled towns, and agricultural or sparsely settled towns.

The former embraces 87 municipalities, including all the 28 cities. None of this number had less than 2,000 inhabitants in each, and only ten had less than 4,000; and each of these smaller towns had one or more villages having a comparatively dense population, living in a district of limited size. The average population of each municipality in this group by the census of 1880 was 15,434. Most of them have a steadily increasing population, a large portion of which consists of immigrants, either of European nativity or from the British North American provinces. In many of the towns of this class there is a rural population of considerable size living in those portions outside the more densely settled villages. The actual increase in population in the rural towns, for the period of twenty years, between the census of 1870 and that of 1890, a period nearly coincident with that under consideration, was 11¼ per cent., while that of the larger or manufacturing and urban districts was 70 per cent.

The other group, of agricultural towns, 259 in number, has but few towns having 3,000 in each, and the average population of each in 1880 was 1,700. Their population is distributed

over an average area of nearly thirty square miles for each township. The principal occupation of the people of these towns consists of dairy farming, market gardening, and other branches of agriculture. A few of these towns are summer resorts, either upon the sea-coast or in the inland region. Some of the towns of this general class have increased slightly in population in the past twenty-five years, many have remained stationary and a considerable number have slowly decreased.

I have included Provincetown and Nantucket in the former class, neither of which is a manufacturing town; but each has a comparatively dense population living in a small area, and a considerable area of nearly unoccupied sandy territory lying outside the densely settled seaport. Both towns are exposed to sea breezes throughout the year. Newton is neither a manufacturing nor a densely settled municipality, but a suburban residential city, with a population consisting mainly of wealthy or comparatively well-to-do inhabitants.

The population of the first group in 1880 was 1,342,782, and that of the second group 440,303. Tables are presented giving the comparative rank of each town for each one of the eight causes of death considered in this paper, together with maps in which the degree of mortality is presented in five grades, as follows: —

1. Towns in which there were no deaths from the disease in question.

2. Towns in which the mortality was *more* than fifty* per cent. *below* that of the State.

3. Towns in which the mortality was *below* that of the State, but not fifty* per cent. below it.

4. Towns in which the mortality was *above* that of the State, but not fifty* per cent. above it.

5. Towns in which the mortality was *more* than fifty* per cent. *above* that of the State.

Even these smaller sub-divisions (the towns) do not convey the exact relation of the mortality rate from any particular disease, since the broad patches of color shown upon the maps

* In the table of general death rates the dividing limits of the groups are placed for the sake of convenience at 15 per cent. instead of 50 per cent.

convey to the eye an impression of quantity in proportion to their areas, while the actual prevalence in towns of small population and large area was in most cases confined to some densely settled village occupying but a small portion of the colored area.

For example, under the head of measles, the neighboring places Fall River and Freetown in Bristol County have a nearly equal area, and the coloring expresses to the eye a similar ratio of mortality to the population only; but the actual number of the population is more than fifty times greater in Fall River than it is in Freetown.

It would have been a very important and valuable addition to this inquiry if the prevalence of sickness from the same causes, independent of mortality, could have been presented. No extended and complete inquiry of this character has been undertaken in the State since the limited inquiry of the Massachusetts Medical Society in 1858 and 1859, and that of the State Board of Health in 1874; consequently we must trust to the information contained in the registration reports, which present only the data of mortality.

The writer has found valuable assistance in the following published reports: —

Dr. Bowditch's well-known report to the Massachusetts Medical Society in 1862, upon consumption in Massachusetts.

Dr. Geo. Derby's papers upon consumption in the Twenty-fourth Registration Report of Massachusetts, 1865, and typhoid fever in the second report of the State Board of Health, 1871.

Dr. C. F. Folsom's statistical tables upon diphtheria in the Thirty-ninth Registration Report of Massachusetts, 1880, and upon typhoid fever in the Fortieth Registration Report, 1881.

A study of phthisis and pneumonia in Massachusetts, statistical and climatological, by W. E. Smith, M.D., 1888.

The etiology and treatment of the summer diarrhœa of infants, by Dr. H. C. Haven, Boston, 1886.

Also in the valuable English reports of Dr. Haviland upon the geographical distribution of certain diseases in Great Britain, 1875, and in the excellent work of Dr. Longstaff, entitled "Statistical Studies," 1891.

General Description of the State.

Topographical and Climatic Features.

The State of Massachusetts is one of the older and smaller States of the North American Union. In area it has a surface of about 8,000 square miles (21,000 sq. kilo.).

As compared with the other States of the Union it is one of the least in area. There are but four smaller States. Texas has an area about thirty-three times as large. Massachusetts extends over an average breadth of one degree in latitude and three or more in longitude, the extremes of latitude being 41° 15′ and 42° 53′ N., and those of longitude being 70° and 73° 31′ W.

The land of the south-east and the island portions is low and sandy, and rises gradually toward the western border, where the northerly portion of the Appalachian range of mountains traverses the State from north-east to south-west. The average elevation of the western county is not far from 1,000 feet, with occasional elevations of 2,000 and one of 3,500 feet.

The climate presents extremes which are trying to persons of delicate constitutions. Occasional temperatures of 20° below zero (Fahr.) in winter and of 100° above in summer are recorded. The mean average temperature at Boston is about 48°, and is one or more degrees lower in the western counties. Sudden changes are common, and the passage from winter to summer is often rapid. The climate of the south-eastern portion and the two islands is much more equable than that of the interior. The ground often freezes to a depth of three feet, and snow covers the ground to a depth of two feet or more, in winter, especially in the western counties. The average annual rainfall is from forty to forty-five inches.

The State has an irregular sea-coast line of nearly three hundred miles.

Population.

The State was settled in 1620 by the English, and for nearly two centuries the English constituted by far the predominant nationality represented. Since 1840 immigration from various other sources has been rapid.

Massachusetts has also contributed more than one and one-half millions of its population to the Western States.

No census was taken until 1765, in which year the State had 238,195 inhabitants. The following table presents the number of inhabitants at each succeeding census: —

Population of Massachusetts.

YEAR.	Population.	YEAR.	Population.
1765, ...	238,195	1840, ...	737,700
1790, ...	378,787	1850, ...	994,514
1800, ...	422,845	1860, ...	1,231,066
1810, ...	472,040	1870, ...	1,457,351
1820, ...	523,287	1880, ...	1,783,085
1830, ...	610,408	1890, ...	2,238,943

By the State census of 1885 there was an excess of 76,373 females, and the ratio of males to females was 100 to 109. The age period 20–40 contributed more than one-half of this excess, a fact which is doubtless chiefly due to the emigration of males of these ages to the Western States.

The population of the State at the census of 1880 consisted of 72.9 per cent. of persons of native birth, and 27.1 per cent. of foreign birth. Turning back to the previous generation, however, we find that of the parents of this population 48.1 per cent. only were of native birth, and 51.9 per cent. were of foreign birth.

The accessions to the population by immigration during the past fifty years have been mainly from Ireland, the British North American Provinces, Scotland, Germany, France, Italy and Sweden. For the past twenty years a large part of the accession from the British Provinces was of French Canadian origin.

The term *native* must be taken in a comparative sense, since the entire population is made up either of people of foreign origin, or their descendants of such class, to the number of from one to ten generations.

No allusion is here made to the aboriginal inhabitants, of whom there are less than 500 now living in the State, and of these but few are of unmixed Indian origin. They occupy two small sea-shore towns.

Density.

The State is more densely settled than any other State of the Union except Rhode Island. The average density of the population was 222 per square mile by census of 1880, and 278 by census of 1890. The population is very unevenly distributed, as is shown in the following table: —

Statistics of Counties, Areas, Population, Density, Total Deaths and Death Rates (1871–90).

COUNTIES.	Area in Square Miles.	Population.		Density. Persons to Square Miles.		Acres to Each Person.		Total Deaths. 1871-90.	Annual Death Rate. 1871-90.
		1880.	1890.	1880.	1890.	1880.	1890.		
Barnstable, .	373	31,897	29,172	85.5	78.2	7.5	8.2	11,452	17.95
Berkshire, .	959	69,032	81,108	72.0	84.6	8.9	7.6	24,359	17.64
Bristol, . .	557	139,040	186,465	249.6	334.8	2.5	1.9	58,880	21.20
Dukes, . .	124	4,300	4,369	34.7	35.2	18.4	18.2	1,682	19.55
Essex, . .	503	244,535	299,985	486.0	596.0	1.3	1.1	96,241	19.67
Franklin, . .	665	36,001	38,610	54.1	56.5	11.8	11.3	11,806	16.40
Hampden, .	634	104,142	135,713	164.2	214.0	3.9	3.0	41,135	19.75
Hampshire, .	572	47,232	51,859	82.6	90.6	7.7	7.1	17,024	18.02
Middlesex, .	827	317,830	431,167	379.0	521.0	1.7	1.2	126,473	19.89
Nantucket, .	65	3,727	3,268	57.3	50.3	11.2	12.7	2,062	27.66
Norfolk, . .	494	96,507	118,950	195.3	240.8	3.3	2.7	32,673	16.93
Plymouth, .	671	74,018	92,700	110.3	138.1	5.9	4.6	26,003	17.56
Suffolk, . .	45	387,927	484,780	8,620.0	10,773.0	.07	.06	184,620	23.80
Worcester, .	1,551	226,897	280,787	146.3	181.1	4.4	3.5	83,737	18.45
THE STATE,	**8,040**	**1,783,085**	**2,238,943**	**221.8**	**278.5**	**2.9**	**2.3**	**718,147**	**19.66**

A north and south line, dividing the population into two equal parts, passes through the cities of Haverhill, Somerville, Cambridge, Taunton, Fall River and Boston, dividing the latter about two miles west of the State House.

Massachusetts has followed the example of most civilized countries in the rapid increase of its urban as compared with its rural districts. Some of the cities and towns have doubled their population within a period of ten or fifteen years. On the other hand, in very many of the small towns, which occupy districts remote from railway travel, the population has for many years been stationary, and, in not a few, diminishing.

Some towns have a smaller population than they had at the census of 1790.

About thirty-eight per cent. of the population live within a radius of ten miles of Boston.

Vital Statistics.

The marriage, birth and death rates of the State for the past forty years are shown in the following table: —

PERIODS.	Marriage Rates (Persons married).	Birth Rates.	Death Rates.	Excess of Births over Deaths.
1851-55,	23.4	28.9	18.7	10.2
1856-60,	19.6	29.5	17.9	11.6
(Civil war), 1861-65,	18.7	25.3	20.7	4.6
1866-70,	21.0	26.1	18.2	7.9
1871-75,	19.8	27.6	20.8	6.8
(Financial depression), 1876-80,	16.0	24.7	19.2	5.5
1881-85,	18.5	25.1	19.8	5.3
1886-90,	18.6	25.9	19.4	6.5

The birth rates and death rates of the urban and the rural population for the census years are shown in the following tables: —

Birth Rates per 1,000.

LOCALITY.	1865.	1870.	1875.	1880.	1885.	1890.
Cities,	25.7	27.2	29.7	27.6	27.8	28.4
Remainder of the State,	22.6	25.6	23.8	20.9	21.3	21.7
Whole State,	23.9	26.2	26.6	24.8	25.1	25.8

Death Rates.

LOCALITY.	1865.	1870.	1875.	1880.	1885.	1890.
Cities,	22.1	20.9	23.1	21.5	21.1	20.6
Remainder of the State,	19.8	16.6	18.6	17.5	17.5	17.5
Whole State,	20.6	18.7	21.2	19.8	19.6	19.4

The whole number of deaths registered in the State for the twenty years 1871–90 was 718,147.

The number of deaths from the eight different causes considered in this paper was 288,348, or 40.1 per cent. of the total mortality. These were distributed as follows: —

Small-pox,	2,298	Typhoid fever,	19,421
Measles,	3,984	Cholera infantum,	42,375
Scarlet-fever,	14,639	Phthisis,	112,604
Diphtheria and croup,	36,553	Pneumonia,	56,474

THE COUNTIES.

Some general features of the counties may be outlined, beginning with the western border of the State.

Berkshire County consists mainly of high land, its average level being nearly 1,000 feet above the sea. There are many mountains and hills of 1,500 to 3,500 feet, with deep valleys and swift water courses. There is an abundance of forest land. There are a few thriving manufacturing towns. The manufacture of paper is largely carried on upon the pure, clear water courses of this county. The population of the county slowly increases, but in many of the small towns remote from railway travel it has retrograded. The average density of the population is 85 per square mile (census of 1890).

The winters are long and severe, the snow often lying upon the ground in the forests, especially in the northern portion, until late in April.

The next three counties may be considered together. Franklin, Hampshire and Hampden counties lie upon the east and west sides of the Connecticut River, in the order named, from north to south. The land in the first two named is generally higher than that in Hampden, the southern county of the group. The Connecticut River divides them all nearly in twain, while four tributaries drain the areas upon each side, entering the Connecticut at nearly opposite points upon each side of the river.

The population of Franklin and Hampshire counties is chiefly agricultural, while that of Hampden has a much greater manufacturing population, distributed in several rapidly increasing cities and towns.

The density of population in these counties is as follows: Franklin, 56.5 per square mile; Hampshire, 90.6 per square mile; and Hampden, 214 per square mile.

Worcester is the central county of the State, and the largest in area. It is mainly occupied by an agricultural population. It has one large and one small city, and several enterprising manufacturing towns. The land is generally high in the northern portions and lower in the southern. The density of its population is 181 per square mile.

Suffolk is the metropolitan county, and includes the seaport and city of Boston. The county contains about half a million of inhabitants, which gives, with its limited area, a density of nearly 11,000 per square mile.

Middlesex and Norfolk join Suffolk upon the north and south, and are quite densely settled in the suburban portions. The former has a large manufacturing population in some of its towns, and has many towns of extremely rapid growth. Some of them have doubled within the past decade. The density of Middlesex County is 521 per square mile, and that of Norfolk 241.

Essex, the north-eastern county, has a bold, rugged sea-coast, several manufacturing cities of moderate size and healthy growth, and one large fishing port. The land, especially near the coast, presents but few elevations. The Merrimack River passes through its northern portion to the sea. The density of Essex County is 596 per square mile.

Bristol and Plymouth occupy the south-eastern part of the State (exclusive of Cape Cod). They include four thriving manufacturing cities. The growth of Bristol is more rapid than that of Plymouth. The climate is generally milder than that of the counties already named. The density of Bristol County is 335, and of Plymouth 138 per square mile.

Barnstable County is Cape Cod, a long, flat, sandy peninsula, stretching east and northward seventy miles or more. It has no cities or large towns, and its population is diminishing by emigration. The principal occupations are fishing and the culture of cranberries. The climate is insular. Many of the towns are becoming places of summer resort, on account of the equable temperature and facilities for sea-bathing.

The two island counties have similar characteristics to Barnstable. They are sandy islands.

The average density of population of these three counties is about 70 per square mile.

General Death Rate of Counties, Cities and Towns.

In the accompanying tables will be found the death rates of each county, city and town in the State for the twenty years 1871–90, the figures presented being the population of the mid-year of the period (1880), the average annual death rate for the twenty years from all causes, and the rank which each city and town held for the period as compared with the average death rate of the State.

In this table allowance has been made for changes in the population of towns by town divisions during the period.

The following towns, recently constituted, do not appear in the list. Their statistics are included in those of the towns from which they were separated: —

Bourne, incorporated in 1884, statistics included in those of Sandwich.

Millis, incorporated in 1885, statistics included in those of Medway.

Hopedale, incorporated in 1886, statistics included in those of Milford.

North Attleborough, incorporated in 1887, statistics included in those of Attleborough.

Avon, incorporated in 1888, statistics included in those of Stoughton.

The following towns were incorporated in the earlier part of the twenty-year period, and their statistics are presented in the tables for the number of years since they were incorporated: Maynard, 1871; Ayer, 1871; Holbrook, 1872; Norwood, 1872; Rockland, 1874; South Abington, 1875; Merrimac, 1876; Hampden, 1878; North Adams, 1878; Cottage City, 1880; and Wellesley, 1881.

Brighton, Charlestown and West Roxbury were annexed to Boston in 1873.

The names of the following were changed during the twenty-year period: North Chelsea to Revere; South Scituate to Norwell; South Abington to Whitman; North Bridgewater to Brockton.

The populations of all cities and towns marked (*) have been re-estimated in calculating the death rate, in consequence of an unequal rate of increase during the period.

The deaths in the large public institutions in Danvers, Tewksbury, Monson, Bridgewater, Worcester, Taunton, Northampton,

Somerville and Westborough have been omitted in estimating the death rates of those places.

At the head of the list with lowest mortality rate stands Gosnold, the smallest in population in the State, a long, wind-swept series of islands at the mouth of Buzzard's Bay. In this town there were no deaths from pneumonia, small-pox, typhoid fever, scarlet-fever or measles during the twenty years. Next in the list is New Ashford, another very small town in northern Berkshire, on very high land. Its death rate from consumption was the lowest in the State. Richmond has a similar location. Nahant is a rocky promontory jutting out into the sea, with a small population, largely increased in the summer. Tewksbury is an inland agricultural town, whose death rate does not appear to have been increased by its proximity to a large city. In this town and also in Monson, both of which have low death rates, there have existed two large State institutions during the whole period, with mortality rates higher than that of the State, in one case very excessive, and yet the death rates of the towns do not appear to have been increased thereby.

The position of Berkshire County in this list is worthy of note, since it had not a single town whose mortality rate during the twenty years was above the average.

The exceptional position of Chilmark is also noticeable, since its death rate was very low (14.07), while those of other towns upon the island of Martha's Vineyard were very high, their death rates being as follows: Tisbury, 20.00; Edgartown, 21.83; Gay Head, 32.91.

Certain groups of contiguous towns are also worthy of note as having low mortality rates: Brookline, Newton, Needham, Wellesley, Weston, Wayland, Lincoln, Concord, Littleton, Boxborough and Stow, all in Middlesex and northern Norfolk counties; Burlington, Billerica, Tewksbury and Dracut, in the northern part of Middlesex; Erving, Gill, Greenfield, Leyden, Colrain and Heath, along the northern border of Franklin County; Clarksburg, Williamstown, New Ashford and Lanesborough, in north-western Berkshire; Washington, Lenox, Richmond, Stockbridge, Great Barrington, Tyringham, Otis, Sandisfield, New Marlborough and Mt. Washington, in southern Berkshire; Warren, Palmer, Monson and Wales, on the border of Worcester and Hampden counties; Franklin, Wrentham

and Foxborough, in western Norfolk; Norwood, Canton and Milton, in central Norfolk; Rockland, Whitman and Hanson, in northern Plymouth.

The number of towns having comparatively low mortality rates in south-eastern Massachusetts, embracing the five counties of Bristol, Plymouth, Barnstable, Dukes and Nantucket, was quite small.

Omitting consideration of the cities for the present, the following towns stand prominent at the extreme of high mortality, and in the following order: Gay Head, Nantucket, Orleans, Edgartown and Mashpee. All these are sea-shore towns; three of them are upon islands. First of all is the small Indian town of Gay Head, which also stands at the extreme of high mortality in the lists of phthisis and measles. Singularly enough, it is just opposite and across Vineyard Sound from Gosnold, which stands at the other extreme, of low mortality. Next comes the town of Nantucket, once a thriving fishing port, and now a summer resort. In estimating the death rate of this town the deaths of the summer visitors have been omitted. These would have increased the death rate, and given it a rank of 141 instead of 137 in the list.

So far as healthful climate and good location is concerned, these towns can scarcely be surpassed; they have an equable temperature, and are swept by sea breezes. Other conditions must therefore be sought to account for high mortality rates. The following applies generally to these five towns: in consequence of the emigration of the young and vigorous adults, the resident population of these towns has an excess of elderly people, whose death rate is naturally high. The number of people over seventy years of age living in these towns by the State census of 1885 was 603, which was 10.1 per cent. of the total population, while the population of this class in the State at large was but 3.3 per cent. Added to this condition, in Nantucket (which contains more than half the population of the five towns) is the crowding of most of its population into one compact village, having no efficient system of sewerage.

I am inclined to regard the high ratio of Gay Head and Mashpee, in the general mortality list, as probably due partly to the character of the population and not to geographical position. The mixture of Indian and Negro races in these two

towns is shown in the experience of other States to succumb early to infectious diseases.

In close proximity to the end of the list come the cities of Boston, Fall River, Lowell, Holyoke and Lawrence.

Boston had a high ratio of mortality from all of the diseases under consideration except typhoid fever, its position being very high in the lists for consumption and small-pox.

The principal diseases in which Fall River had a high ratio were scarlet-fever and cholera infantum.

Holyoke had high ratios in small-pox, typhoid fever, cholera infantum and measles.

The principal diseases which proved destructive to Lowell were cholera infantum, small-pox and typhoid fever.

Lawrence had high mortality from typhoid fever, diphtheria, consumption, cholera infantum and measles.

Had the whole number of deaths returned from Gloucester been included in estimating its death rate, its position would have been next below that of Lawrence; but the omission of 2,100 persons lost at sea from fishing vessels during the twenty years reduces its position to 87 in the list.

Of the smaller places which had high ratios from several infectious diseases, Adams had high mortality from cholera infantum, small-pox and diphtheria; Webster from scarlet-fever, diphtheria and cholera infantum; Mashpee and Shutesbury from consumption, typhoid fever and pneumonia; Ware from scarlet-fever and typhoid fever; Dudley from scarlet-fever and pneumonia.

For the sake of comparison with the excellent tables of Dr. Longstaff, presented in the report of the Local Government Board of England of 1887, I have introduced another table intended to conform to Dr. Longstaff's classification. I have in this table divided the fourteen counties into three groups, to which the terms *dense*, *medium* and *sparse* districts are applied, the first applying to those in which there is less than one acre to each person living. This includes only the metropolitan district of Suffolk County. The second (medium) applies to those in which there is more than one acre but less than four acres to each person. This comprises the counties of Essex, Middlesex, Bristol, Norfolk and Hampden. The sparse districts, those in which there are more than four acres to each

person, comprise the remaining counties. In this grouping the small island counties of Dukes and Nantucket are reckoned with Barnstable County, their general characteristics, both of population and of climate, being quite similar. By this grouping the mortality was in the following ratio: —

Dense districts,	1,000
Medium districts,	826
Sparse districts,	760

General Death Rates of Counties.

COUNTIES.	Population, 1880.	Death Rates.	Mortality Rank, the State = 100.
Franklin,	36,001	16.40	84
Norfolk,	96,507	16.93	86
Plymouth,	74,018	17.56	89
Berkshire,	69,032	17.64	90
Barnstable,	31,897	17.95	91
Hampshire,	47,232	18.02	92
Worcester,	226,897	18.45	94
Dukes,	4,300	19.55	99
THE STATE,	1,783,085	19.66	100
Essex,	244,535	19.67	100
Hampden,	104,142	19.75	101
Middlesex,	317,830	19.89	101
Bristol,	139,040	21.20	108
Suffolk,	387,927	23.80	121
Nantucket,	3,727	27.66	141

Counties grouped according to their Density of Population.	COUNTIES.	Acres to each Person. 1880.		Death Rates, the State = 100.	
I. County in which there is less than one acre to each person,	Suffolk,	.07		121	
II. Counties having more than one acre but less than four acres to each person,	Essex,	1.3	Average, 2.1.	100	Average, 100.
	Middlesex,	1.7		101	
	Bristol,	2.5		108	
	Norfolk,	3.3		86	
	Hampden,	3.9		101	
III. Counties having more than four acres to each person,	Worcester,	4.4	Average, 6.4.	94	Average, 92.
	Plymouth,	5.9		89	
	Hampshire,	7.7		92	
	Berkshire,	8.9		90	
	Barnstable, Dukes and Nantucket,	9.0		97	
	Franklin,	11.8		84	

General Death Rates of Cities and Towns for Twenty Years, 1871–90.

[The population of all towns marked (*) has been re-estimated, in calculating the death rate.]

Cities and towns in which the death rate was more than fifteen per cent. below that of the State: —

Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.	Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.
Gosnold,	152	8.88	45	Otis,	785	14.58	74
New Ashford,	203	9.36	48	Holden,	2,499	14.59	74
Richmond,	1,124	11.34	58	*Lenox,	2,043	14.60	74
*Hull,	383	11.56	59	Raynham,	1,681	14.63	74
Nahant,	808	11.75	60	Westborough,	5,214	14.63	74
Tewksbury,	2,179	11.91	61	Whately,	1,074	14.66	75
†Wellesley,	3,013	12.24	62	¶Rockland,	4,553	14.66	75
Mt. Washington,	205	12.44	63	*Saugus,	2,625	14.66	75
Weston,	1,448	12.46	63	Erving,	872	14.68	75
Lincoln,	907	12.73	65	*Greenfield,	3,903	14.68	75
Concord,	3,922	12.80	65	Auburn,	1,317	14.69	75
Clarksburg,	724	13.12	67	*Needham,	5,252	14.70	75
Leyden,	507	13.31	68	Hamilton,	935	14.76	75
Wales,	1,030	13.35	68	Wayland,	1,962	14.78	75
Boxborough,	319	13.48	69	Charlton,	1,900	14.80	75
Gill,	733	13.57	69	Southwick,	1,104	14.81	75
Newbury,	1,566	13.57	69	Harwich,	3,265	14.82	75
Monson,	3,758	13.62	69	Billerica,	2,000	14.82	75
Colrain,	1,777	13.70	70	Foxborough,	2,950	14.83	75
‡*Whitman,	3,024	13.73	70	Middlefield,	648	14.89	76
Tyringham,	542	13.74	70	Littleton,	994	14.89	76
*Newton,	16,995	13.79	70	Sandisfield,	1,107	14.90	76
New Marlborough,	1,876	13.80	70	Wrentham,	2,481	15.03	76
Southborough,	2,142	13.82	70	Stow,	1,045	15.07	77
Burlington,	711	13.92	71	Canton,	4,516	15.10	77
Dracut,	1,595	13.92	71	Hanson,	1,309	15.16	77
§*Cottage City,	820	13.96	71	Warren,	3,889	15.23	77
‖*Norwood,	2,345	13.99	71	Great Barrington,	4,653	15.23	77
Chilmark,	494	14.07	72	*Milton,	3,206	15.28	78
Franklin,	4,051	14.08	72	Lanesborough,	1,286	15.31	78
Heath,	560	14.10	72	Cummington,	881	15.32	78
Tolland,	452	14.16	72	Middleborough,	5,237	15.34	78
Hawley,	592	14.19	72	*Williamstown,	3,394	15.37	78
Swampscott,	2,500	14.20	72	Boylston,	854	15.40	78
Stockbridge,	2,357	14.23	72	Palmer,	5,504	15.46	79
Washington,	493	14.30	73	Acushnet,	1,105	15.47	79
Winchester,	3,802	14.35	73	Conway,	1,760	15.48	79
‖Holbrook,	2,130	14.35	73	Egremont,	875	15.54	79
*Revere,	2,263	14.39	73	Chester,	1,473	15.54	79
Berkley,	927	14.45	74	Norton,	1,782	15.55	79
*Brookline,	8,057	14.47	74	Berlin,	977	15.55	79
New Braintree,	610	14.51	74	Groveland,	2,227	15.58	79
*Melrose,	4,560	14.52	74	*Everett,	4,159	15.60	79
Amherst,	4,298	14.55	74	Westford,	2,147	15.60	79

† Ten years only. ‡ Sixteen years only. § Eleven years only. ‖ Nineteen years only. ¶ Seventeen years only.

General Death Rates, etc., for Twenty Years, 1871-90 — Continued.

Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.	Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.
Savoy,	715	15.60	79	Ashfield,	1,066	16.08	82
Medfield,	1,371	15.61	79	Topsfield,	1,165	16.09	82
Deerfield,	3,543	15.62	79	Dunstable,	453	16.11	82
Danvers,	6,598	15.66	80	Easton,	3,902	16.13	82
West Brookfield,	1,917	15.67	80	Lancaster,	2,008	16.13	82
Bridgewater,	3,620	15.67	80	Georgetown,	2,231	16.18	82
West Bridgewater,	1,665	15.67	80	Goshen,	327	16.21	82
Chelmsford,	2,553	15.69	80	Salisbury,	4,079	16.23	83
Attleborough,	11,111	15.73	80	*TAUNTON,	21,213	16.24	83
Reading,	3,181	15.73	80	Shelburne,	1,621	16.25	83
*Medford,	7,573	15.74	80	Middleton,	1,000	16.25	83
Shirley,	1,365	15.75	80	North Brookfield,	4,459	16.25	83
*BROCKTON,	13,608	15.75	80	*FITCHBURG,	12,429	16.26	83
*Monroe,	166	15.76	80	Warwick,	713	16.27	83
Boxford,	824	15.77	80	Hancock,	642	16.27	83
Hatfield,	1,495	15.78	80	Marshfield,	1,781	16.28	83
Phillipston,	621	15.78	80	Rehoboth,	1,891	16.29	83
*WALTHAM,	11,712	15.78	80	†Hampden,	958	16.32	83
Wendell,	465	15.80	80	Natick,	8,479	16.32	83
Granville,	1,205	15.81	80	Lakeville,	1,008	16.32	83
*Mansfield,	2,765	15.82	80	Mattapoisett,	1,365	16.34	83
Orange,	3,169	15.82	80	*Framingham,	6,235	16.34	83
Windsor,	644	15.83	81	Sunderland,	755	16.35	83
Hardwick,	2,233	15.83	81	*Athol,	4,307	16.37	83
West Newbury,	1,989	15.86	81	Williamsburg,	2,234	16.38	83
*NORTHAMPTON,	12,172	15.87	81	Sherborn,	1,401	16.42	84
Cheshire,	1,537	15.90	81	*Leominster,	5,772	16.44	84
Blackstone,	4,907	15.91	81	Sheffield,	2,204	16.45	84
Sandwich,	3,543	15.92	81	*MALDEN,	12,017	16.45	84
Weymouth,	10,570	15.93	81	‡Merrimac,	2,237	16.46	84
*Hudson,	3,739	15.93	81	Lynnfield,	686	16.47	84
Maynard,	2,291	15.93	81	Dighton,	1,791	16.49	84
Hopkinton,	4,601	15.96	81	*Clinton,	8,029	16.52	84
Uxbridge,	3,111	15.97	81	Hanover,	1,897	16.52	84
Carver,	1,039	15.98	81	North Andover,	3,217	16.55	84
Upton,	2,023	16.02	81	Northborough,	1,676	16.55	84
*Bradford,	2,643	16.07	82	Rowley,	1,201	16.57	84
Beverly,	8,456	16.08	82				

Cities and towns in which the death rate was below that of the State but not fifteen per cent. below it: —

Methuen,	4,392	16.62	85	Pelham,	614	16.70	85
Rochester,	1,043	16.63	85	Medway,	3,956	16.71	85
*Winthrop,	1,043	16.64	85	Peru,	403	16.74	85
Montgomery,	303	16.67	85	Ludlow,	1,526	16.74	85
Westport,	2,894	16.69	85	Swanzey,	1,355	16.79	85

† Thirteen years only. ‡ Fourteen years only.

General Death Rates, etc., for Twenty Years, 1871-90 — Continued.

Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.	Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.
Dalton,	2,052	16.81	86	Walpole,	2,494	17.62	90
Pembroke,	1,405	16.83	86	East Bridgewater,	2,710	17.64	90
Blandford,	979	16.85	86	Mendon,	1,094	17.64	90
Andover,	5,169	16.85	86	†*North Adams,	10,191	17.71	90
Bernardston,	934	16.86	86	Princeton,	1,100	17.73	90
*Florida,	459	16.87	86	Charlemont,	932	17.75	90
Wenham,	889	16.87	86	Dover,	653	17.76	90
Stoneham,	4,890	16.87	86	Plymouth,	7,093	17.76	90
Norfolk,	930	16.93	86	*PITTSFIELD,	13,364	17.80	91
Marion,	958	16.96	86	Russell,	823	17.80	91
West Stockbridge,	1,923	16.97	86	Wareham,	2,896	11.80	91
*GLOUCESTER,	19,329	17.00	87	Grafton,	4,030	17.80	91
Dartmouth,	3,430	17.01	87	Buckland,	1,739	17.82	91
*Watertown,	5,426	17.04	87	Norwell,	1,820	17.83	91
Sutton,	3,105	17.05	87	Rowe,	502	17.83	91
*Lexington,	2,460	17.05	87	*Gardner,	4,988	17.84	91
Holland,	302	17.05	87	*Ashburnham,	1,666	17.88	91
Sudbury,	1,178	17.06	87	Ashland,	2,394	17.92	91
Plainfield,	457	17.07	87	Holliston,	3,098	17.93	91
South Hadley,	3,538	17.07	87	Northfield,	1,603	17.93	91
Templeton,	2,789	17.08	87	Millbury,	4,741	17.97	91
Becket,	1,123	17.10	87	Barnstable,	4,242	17.99	92
Acton,	1,797	17.11	87	Shrewsbury,	1,500	18.00	92
Rutland,	1,059	17.18	87	Winchendon,	3,722	18.00	92
Granby,	753	17.26	88	Manchester,	1,640	18.00	92
Kingston,	1,524	17.26	88	*SOMERVILLE,	24,933	18.04	92
Brewster,	1,144	17.26	88	Wellfleet,	1,875	18.05	92
*MARLBOROUGH,	10,127	17.28	88	*Longmeadow,	1,401	18.06	92
Easthampton,	4,206	17.28	88	Spencer,	7,466	18.08	92
Prescott,	460	17.28	88	Brookfield,	2,820	18.10	92
Groton,	1,862	17.29	88	*LYNN,	38,274	18.12	92
Dedham,	6,233	17.32	88	Sturbridge,	2,062	18.14	92
Fairhaven,	2,875	17.32	88	Dana,	736	18.14	92
Brimfield,	1,203	17.33	88	Barre,	2,419	18.15	92
Eastham,	692	17.34	88	Leicester,	2,779	18.15	92
Duxbury,	2,196	17.35	88	*WOBURN,	10,931	18.15	92
Belmont,	1,615	17.40	88	Bolton,	903	18.16	92
*Wakefield,	5,547	17.47	89	*QUINCY,	10,570	18.21	93
Oakham,	869	17.50	89	Hingham,	4,485	18.23	93
*Braintree,	3,855	17.51	89	Monterey,	685	18.26	93
Ayer,	1,881	17.52	89	Enfield,	1,043	18.26	93
*Hyde Park,	7,088	17.53	89	Royalston,	1,192	18.29	93
Cohasset,	2,182	17.53	89	Westhampton,	563	18.29	93
Worthington,	758	17.54	89	Belchertown,	2,346	18.31	93
Essex,	1,670	17.54	89	*Adams,	5,591	18.32	93
Chesterfield,	769	17.55	89	*HAVERHILL,	18,472	18.33	93
*Westfield,	7,587	17.56	89	Truro,	1,017	18.33	93

† Thirteen years only.

General Death Rates, etc., for Twenty Years, 1871-90 — Concluded.

Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.	Cities and Towns.	Population, 1880.	Death Rate.	Rank, the State =100.
Oxford,	2,604	18.35	93	Provincetown,	4,346	18.90	96
West Boylston,	2,994	18.42	94	Stoughton,	4,875	18.91	96
Ashby,	914	18.43	94	Agawam,	2,216	18.95	96
Lee,	3,939	18.43	94	*Springfield,	33,340	18.99	97
Dudley,	2,803	18.44	94	*Pepperell,	2,348	19.00	97
Chatham,	2,250	18.44	94	Huntington,	1,236	19.01	97
Dennis,	3,238	18.46	94	Leverett,	742	19.07	97
Bedford,	931	18.47	94	Bellingham,	1,223	19.10	97
Yarmouth,	2,173	18.50	94	Sharon,	1,492	19.13	97
Harvard,	1,253	18.51	94	Wilbraham,	1,628	19.13	97
*Worcester,	58,291	18.53	94	*Chelsea,	21,782	19.20	98
Wilmington,	933	18.54	94	West Springfield,	4,149	19.21	98
Sterling,	1,414	18.56	94	Greenwich,	633	19.27	98
Northbridge,	4,053	18.58	94	Hinsdale,	1,595	19.34	98
*Peabody,	9,028	18.58	94	Freetown,	1,329	19.38	99
Tyngsborough,	631	18.62	95	Alford,	348	19.40	99
Scituate,	2,466	18.63	95	Westminster,	1,652	19.43	99
Hubbardston,	1,386	18.65	95	Townsend,	1,967	19.44	99
Halifax,	542	18.72	95	Rockport,	3,912	19.45	99
Southbridge,	6,464	18.72	95	Falmouth,	2,422	19.49	99
Hadley,	1,938	18.73	95	Abington,	3,697	19.50	99
Somerset,	2,006	18.76	95	New Salem,	869	19.56	99
Arlington,	4,100	18.79	96	*Montague,	4,875	19.61	100
Lunenburg,	1,101	18.80	96				
Petersham,	1,109	18.85	96	**THE STATE,**	**1,783,085**	**19.66**	**100**

Towns in which the mortality was above that of the State but not fifteen per cent. above it: —

Paxton,	592	19.68	100	Ipswich,	3,699	20.54	104
*Amesbury,	3,355	19.70	100	Seekonk,	1,227	20.66	105
Plympton,	694	19.74	100	*Southampton,	1,046	20.75	105
Randolph,	4,027	19.77	101	Webster,	5,696	20.75	105
North Reading,	900	19.83	101	*Ware,	4,817	20.94	106
Milford,	9,310	19.84	101	Chicopee,	11,286	21.02	107
Douglas,	2,241	19.90	101	Mashpee,	346	21.24	108
Tisbury,	1,518	20.00	102	Newburyport,	13,538	21.33	108
*Carlisle,	478	20.09	102	*Salem,	27,563	21.54	109
*Cambridge,	52,669	20.15	102	*Edgartown,	1,303	21.88	110
Shutesbury,	529	20.22	103	Orleans,	1,294	21.75	111
*New Bedford,	26,845	20.33	103	*Lawrence,	39,151	22.46	114
Marblehead,	7,467	20.37	104				

Towns in which the mortality was more than fifteen per cent. above that of the State: —

*Holyoke,	21,915	22.83	116	*Boston,	362,839	24.77	126
*Lowell,	59,475	23.18	118	*Nantucket,	3,727	26.99	137
*Fall River,	48,961	24.32	124	Gay Head,	161	32.91	167

Measles.

The statistics of measles for the period under consideration do not present any very striking characteristics with reference to geographical distribution.

The number of deaths from measles registered in Massachusetts during the period of twenty years (1871–90) was 3,984. The percentage of deaths from this cause to the mortality from all causes was .55.

The annual mortality per 10,000 of the living population for each year of the same period from this cause was as follows: —

Annual Death Rate from Measles per 10,000 of the Population. Massachusetts (1871–90).

YEARS.	Death Rate per 10,000 from Measles.	YEARS.	Death Rate per 10,000 from Measles.
1871,	.9	1881,	1.3
1872,	2.8	1882,	.4
1873,	1.1	1883,	1.7
1874,	1.0	1884,	.4
1875,	1.4	1885,	1.6
1876,	.3	1886,	.6
1877,	.8	1887,	2.3
1878,	1.8	1888,	1.1
1879,	.1	1889,	.8
1880,	1.3	1890,	.5
Average, 1871-80,	1.14	Average, 1881-90,	1.05
Average of the whole period,			1.11

By this table it appears that the mortality from measles was extremely variable, the extremes being .1 per 10,000 in 1879 and 2.8 in 1872. There was a slight decrease in the second decade, as compared with the first.

The mortality from this cause for the first five years of the period was.	1,133
For the second five years,	754
For the third five years,	1,007
For the fourth five years,	1,090
	3,984

By counties the ratios for the whole period of twenty years were as follows: —

COUNTIES.	Deaths from Measles, 1871-90.	Death Rate per 10,000 of the Population.	Death Rate per 10,000 of Children under 10 Years.
Barnstable,	22	.34	2.0
Berkshire,	117	.85	3.9
Bristol,	302	1.08	5.4
Dukes,	2	.23	1.8
Essex,	414	.85	4.5
Franklin,	39	.54	2.8
Hampden,	351	1.68	8.2
Hampshire,	81	.85	4.6
Middlesex,	608	.96	4.8
Nantucket,	1	.13	1.0
Norfolk,	86	.44	2.3
Plymouth,	63	.42	2.4
Suffolk,	1,416	1.82	9.9
Worcester,	482	1.06	5.1
THE STATE,	3,984	1.11	5.7

In examining the foregoing table, in connection with the Map No. 1, it appears in general that the sea-coast counties suffered least of all, and of these the counties situated farthest from the principal centres of population had the lowest mortality rates from measles, that of Nantucket, the most remote, being but .13 per 10,000 (representing, however, but one death in a population of 3,727 by census of 1880); that of Dukes County was .23; Barnstable, .34; Plymouth, .42; and Norfolk, .44; that of the State being 1.11. In the same table is also presented a column giving the ratio of mortality from this cause to the living population of children under ten years of age, since the measles mortality is mainly made up from this class. The comparative ratios in this column do not differ very much from those for the whole population, except in Dukes and Nantucket, where the proportion of children to the entire population is small.

In Berkshire County, which had a death rate from this class of .85 per 10,000, the mortality in the northern or more elevated half of the county was greater than that of the southern (see Map No. 1). Franklin County had a very low mortality

rate, Hampshire lower than the average of the State, and Hampden had an excessively high rate.

In Worcester County the southern half suffered more severely than the northern, while in Middlesex County the mortality from measles was more uniformly distributed, and in general was below the average of the State. In Essex the mortality from measles was quite uniformly distributed, and was less than that of Middlesex.

In examining these counties with reference to the effect of density of population, the differences are much more marked than those which relate merely to geographical position.

In the following table the counties are arranged with reference to their death rates from measles, the mortality of the State from this cause for the period in question being considered as 100: —

Counties of Massachusetts arranged according to their Death Rates from Measles (1871-90), that of the State being taken as 100, the Density of Population being expressed in Acres to Each Person.

COUNTIES.	Density of Population. Acres to Each Person (Census of 1880).	Mortality Rank from Measles, that of the State = 100.	
		Mortality Rank, Total Population.	Mortality Rank, Children under 10.
Nantucket,	11.2	12	24
Dukes,	18.4	21	31
Barnstable,	7.5	31	35
Plymouth,	5.9	38	42
Norfolk,	3.3	40	40
Franklin,	11.8	49	49
Hampshire,	7.7	77	81
Berkshire,	8.9	77	69
Essex,	1.3	77	79
Middlesex,	1.7	86	85
Worcester,	2.4	95	90
Bristol,	2.5	97	95
THE STATE,	2.9	100	100
Hampden,	3.9	151	145
Suffolk,	.07	164	175

In further consideration of this point, I have arranged the counties in three groups, according to their density of population, as in the following table: —

Counties grouped according to their Density of Population.	Counties.	Persons to Square Mile (Census of 1880).	Acres to Each Person.	Death Rate or Mortality Rank for Measles, the State = 100.
I. County in which there is less than one acre to each person living,	Suffolk,	8,620	.07	164
II. Counties having more than one acre but less than four acres to each person,	Essex,	486	1.3	77
	Middlesex,	379	1.7	86
	Bristol,	250	2.5	97
	Norfolk,	195	3.3	40
	Hampden,	164	3.9	151
		Average, 299.	Average, 2.1.	Average, 93.
III. Counties having more than four acres to each person,	Worcester,	146	4.4	95
	Plymouth,	110	5.9	38
	Hampshire,	83	7.7	77
	Berkshire,	85	8.9	77
	Barnstable, Dukes and Nantucket,	71	9.0	28
	Franklin,	51	11.8	39
		Average, 99.	Average, 6.4.	Average, 73.
THE STATE,		222	2.9	100

An examination of the foregoing table shows in general that the mortality rate for measles in the three districts bears a tolerably definite relation to the density of population in those districts, being highest in the metropolitan district of Suffolk County, medium in the districts of intermediate density, and lowest in the sparsely settled counties, or more exactly as follows: —

Mortality of *dense* districts from measles,	1,000
Mortality of *medium* districts,	517
Mortality of *sparse* districts,	445

The marked exceptions or departures from the average of the class in the case of populous counties are those of Hampden and Norfolk. The former had an exceptionally high mortality rate from measles and the latter was as exceptionally low.

The high rate of Hampden appears to be due to an excessive mortality from this cause in the city of Holyoke, a city in which the growth during the period under consideration was very rapid, the foreign population large, and the birth rate

higher than that of any other city in the State. (The population of Holyoke in 1870 was 10,733; in 1890, 35,637. Its average birth rate for the twenty years was 39.6, that of 1885 being 45.9 and that of 1890 42.7 per 1,000 of the population.) Hence the ratio of young children in Holyoke liable to measles was unusually large. Leaving Holyoke out of the county, the remaining cities and towns of Hampden County had a mortality rate from measles which would give them an average rank of but 101, that of the State being 100.

The low mortality rate of Norfolk County from measles may be taken as a result of the comparative uniformity with which its population is distributed. It is not only more sparsely settled than the average of the counties of its group, but the population is also nowhere aggregated into populous cities having a crowded tenement population.

Classification by Towns.

A table is presented in which the cities and towns of Massachusetts are classified with reference to their mortality from measles. In this table the mortality rate of the State is represented as 100, and that of each city and town is given its proper position either above or below that of the State.

A map is also presented (see Map No. 1), upon which each town is given its position in one of five classes, after the manner stated upon page 763.

A study of the extremes will be found useful in this connection. At one extreme are 95 towns in which there were no deaths from this cause during the twenty years (1871–90). These were mostly towns of small population; thirteen only of the number had a population of more than 2,000 in each; and five only had more than 3,000 in each at any time during the period in question.

Forty-four of these towns (having no mortality from measles) were not upon any line of railway communication. Medford, Natick and Melrose were the principal towns having low ratios from this cause; the cities of Waltham and Newburyport also had comparatively low ratios. The entire mortality from measles in these five cities and towns for the twenty

years was but 21. In the seven island towns there were but 3 deaths from this cause.

At the other extreme, in the group of cities and towns having a mortality from measles more than fifty per cent. above the average, Holyoke stands highest as a place of considerable size. In the same group having highest ratios were the small towns of Gay Head, Middlefield, Paxton, Carver, Lanesborough, Cummington, Brimfield and Washington. These, however, have but little significance when separately considered, since the addition or subtraction of a single death in either town would make a very decided change in its position. In the same group are to be found the manufacturing towns of Hudson, Spencer, Webster and the three Brookfields, all upon railway lines. The towns of Dracut, West Springfield, Lanesborough and South Hadley are all in close proximity to cities which also had high ratios from this cause.

The position of the cities relative to their mortality from this disease was as follows (the State = 100) : —

Waltham,	17	Cambridge,	87
Newburyport,	37	Springfield,	95
Brockton,	40	Salem,	98
Haverhill,	47	Pittsfield,	99
Taunton,	48	Gloucester,	120
Newton,	50	Chelsea,	120
Malden,	51	Worcester,	142
Woburn,	54	Marlborough,	157
Northampton,	58	Boston,	172
Lynn,	59	Lowell,	173
Fitchburg,	61	Lawrence,	174
Somerville,	70	Fall River,	176
New Bedford,	72	Chicopee,	191
Quincy,	77	Holyoke,	328

The remarkably coincident positions of the densely settled cities of Boston, Lowell, Lawrence, Fall River and Chicopee are worthy of note.

Density of Population. — The annual mortality rate of the 87 densely settled cities and manufacturing towns for the twenty years from this cause was 1.25 per 10,000 (that of the whole State being 1.11) of the living population, and that of the 259 sparsely settled agricultural towns was .53 per 10,000;

or, reckoning that of the dense towns as 1,000, that of the sparsely settled was but 425.

Towns in which there were no deaths from measles during the twenty years, 1871–90:—

Acton.	East Bridgewater.	Lincoln.	Rowley.
Alford.	Eastham.	Longmeadow.	Royalston.
Barnstable.	Edgartown.	Lynnfield.	Russell.
Bedford.	Egremont.	Marshfield.	Savoy.
Bellingham.	Enfield.	Mattapoisett.	Seekonk.
Berkley.	Fairhaven.	Medfield.	Shrewsbury.
Berlin.	Falmouth.	Mendon.	Shutesbury.
Bernardston.	Florida.	Monroe.	Southborough.
Boxborough.	Gill.	Mt. Washington.	Southwick.
Boxford.	Goshen.	Nahant.	Sudbury.
Burlington.	Gosnold.	New Ashford.	Sunderland.
Carlisle.	Granby.	New Braintree.	Tisbury.
Chelmsford.	Granville.	New Marlborough.	Tolland.
Chatham.	Greenwich.	Northborough.	Tyringham.
Chesterfield.	Groveland.	North Reading.	Wales.
Chilmark.	Halifax.	Oakham.	Warren.
Clarksburg.	Harvard.	Otis.	Warwick.
Colrain.	Hinsdale.	Plainfield.	Wendell.
Conway.	Holbrook.	Prescott.	West Newbury.
Cottage City.	Holland.	Princeton.	Whately.
Dana.	Hull.	Rehoboth.	Wilmington.
Deerfield.	Huntington.	Rochester.	Winthrop.
Dighton.	Lee.	Rockland.	Worthington.
Dunstable.	Leicester.	Rowe.	TOTAL, 95.

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Measles in Twenty Years, the State being taken as 100.

Cities and towns in which the mortality from measles was more than fifty per cent. below that of the State:—

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Medford,	1	5	Duxbury,	1	20
Canton,	1	10	Georgetown,	1	20
Natick,	2	11	Hingham,	2	20
Nantucket,	1	12	Tewksbury,	1	20
Dartmouth,	1	13	Westford,	1	21
Westport,	1	15	Lenox,	1	21
Wareham,	1	15	Amherst,	2	21
Foxborough,	1	15	Cohasset,	1	21
Bradford,	1	16	Salisbury,	3	22
WALTHAM,	5	17	Weymouth,	5	22
Melrose,	2	17	Dedham,	3	22
Andover,	2	17	Beverly,	4	22
Wrentham,	1	18	Upton,	1	22
Swampscott,	1	18	Northbridge,	2	22
Stockbridge,	1	19	Lancaster,	2	23
Plymouth,	3	19	Randolph,	2	23

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Measles in Twenty Years, etc. — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Charlton, ...	1	23	Winchendon, . . .	3	36
Ayer, ...	1	23	Walpole, ...	2	36
Easton, ...	2	23	NEWBURYPORT, . .	11	37
West Stockbridge, . .	1	23	Pepperell, . . .	2	38
Wellfleet, ...	1	24	Belchertown, . . .	2	39
Norwell, ...	1	24	Richmond, . . .	1	40
Leominster, . . .	3	24	Becket, ...	1	40
Abington, ...	2	24	BROCKTON, . . .	14	40
Bridgewater, . . .	2	24	Petersham, . . .	1	40
Westborough, . . .	3	26	Sandisfield, . . .	1	40
Manchester, . . .	1	27	Wakefield, . . .	5	40
Danvers, ...	4	27	Acushnet, . . .	1	40
Dennis, ...	2	27	Provincetown, . .	4	42
Westminster, . . .	1	27	Everett, ...	5	42
Milton, ...	2	27	Brookline, . . .	8	42
Essex, ...	1	27	Stow, ...	1	42
Reading, ...	2	28	North Andover, . .	3	42
Harwich, ...	2	28	Southampton, . .	1	43
Merrimac, . . .	1	28	Braintree, . . .	4	43
Northfield, . . .	1	28	Westfield, . . .	8	43
Stoughton, . . .	3	28	Truro, ...	1	44
Attleborough, . . .	7	28	Somerset, . . .	2	44
Newbury, . . .	1	29	Franklin, . . .	4	44
Holliston, ...	2	29	Billerica, . . .	2	45
Cheshire, ...	1	29	Lakeville, . . .	1	45
Kingston, ...	1	30	Stoneham, . . .	5	46
Wellesley, . . .	1	30	Blackstone, . . .	5	46
Sharon, ...	1	30	Wayland, . . .	2	46
Hopkinton, . . .	3	30	HAVERHILL, . . .	20	47
Hatfield, ...	1	30	Hamilton, . . .	1	48
Marblehead, . . .	5	30	Hanover, . . .	2	48
Chester, ...	1	31	Watertown, . . .	6	48
Weston, ...	1	31	TAUNTON, . . .	23	48
Saugus, ...	2	32	Ipswich, ...	4	49
Hubbardston, . . .	1	32	Charlemont, . . .	1	49
Shirley, ...	1	33	Great Barrington, . .	5	49
Rockport, . . .	3	34	Norfolk, ...	1	49
Auburn, ...	1	34	Groton, ...	2	49
Concord, ...	3	34	Ashby, ...	1	50
Middleborough, . .	4	34	NEWTON, . . .	20	50
Norwood, ...	2	35	Sandwich, . . .	4	50
Orleans, ...	1	35	Whitman, . . .	3	50
Needham, . . .	1	35	Wenham, . . .	1	50

Cities and towns in which the mortality from measles was below the average but not fifty per cent. below it: —

Norton, ...	2	51	New Salem, . . .	1	51
MALDEN, ...	16	51	Boylston, . . .	1	52

[illegible] *arranged in the Order of their Death* [illegible] *in Twenty Years, etc.* — Continued.

[illegible]	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
[illegible]	2	53	Easthampton,	7	75
[illegible]	8	53	Hawley,	1	76
[illegible]	3	54	Arlington,	7	77
[illegible]	13	54	QUINCY,	19	77
[illegible]	2	54	Southbridge,	11	77
[illegible]	3	55	Brewster,	2	78
[illegible]	3	56	Maynard,	4	78
N[illegible]AMPTON,	16	58	Hampden,	1	78
[illegible]NN,	52	59	Athol,	8	78
[illegible]on,	5	59	Amesbury,	9	78
Everett,	1	60	Westhampton,	1	80
Peabody,	12	61	Heath,	1	80
FITCHBURG,	20	61	Williamsburg,	4	80
Revere,	4	63	Montague,	8	80
Pembroke,	2	64	Hardwick,	4	81
Templeton,	4	65	Lunenburg,	2	82
Plympton,	1	65	Yarmouth,	4	83
Grafton,	6	67	Belmont,	3	84
Millbury,	7	67	Adams,	19	85
Swanzey,	2	67	Rutland,	2	85
Medway,	6	68	Williamstown,	7	85
Lexington,	4	68	Ashfield,	2	85
Dover,	1	68	Ashburnham,	4	87
Hanson,	2	68	CAMBRIDGE,	105	87
Townsend,	3	68	Leyden,	1	88
Oxford,	4	69	Gardner,	11	89
Hancock,	1	69	Blandford,	2	92
Hadley,	8	69	Marion,	2	94
SOMERVILLE,	41	70	Mansfield,	6	95
Orange,	5	70	SPRINGFIELD,	73	95
Monterey,	1	70	Sterling,	3	95
Winchester,	6	71	Sherborn,	3	96
Tyngsborough,	1	71	Clinton,	17	96
Phillipston,	1	72	SALEM,	60	98
NEW BEDFORD,	52	72	Bolton,	2	99
Milford,	15	72	PITTSFIELD,	30	99
Palmer,	9	73			
Greenfield,	7	75	THE STATE,	3,984	100
Hyde Park,	12	75			

Cities and towns in which the mortality from measles was a[illegible] but not fifty per cent. above it:—

Uxbridge,	7	101	Dalton,	[illegible]	110
Methuen,	10	[illegible]	Wilbraham	[illegible]	110
Erving,	[illegible]	[illegible]	[illegible]elburne,	[illegible]	[illegible]1
Buckland,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sturbridge,	[illegible]	[illegible]	[illegible]d,	[illegible]	[illegible]

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Measles in Twenty Years, etc. — Concluded.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
North Adams,	21	113	Middleton,	3	135
Topsfield,	3	115	West Boylston,	9	135
Ludlow,	4	118	Littleton,	3	135
GLOUCESTER,	52	120	Freetown,	4	135
CHELSEA,	61	120	Windsor,	2	140
Agawam,	6	122	WORCESTER,	191	142
Sheffield,	6	123	Ware,	17	144
Mashpee,	1	130	Pelham,	2	146
Sutton,	9	130	Montgomery,	1	149

Cities and towns in which the mortality from measles was more than fifty per cent. above the average: —

MARLBOROUGH,	136	157	North Brookfield,	19	192
Brookfield,	10	159	Webster,	25	197
Douglas,	8	160	Dracut,	7	197
West Brookfield,	7	164	Spencer,	33	199
BOSTON,	1,368	172	Cummington,	4	204
LOWELL,	222	173	West Springfield,	19	206
LAWRENCE,	144	174	Lanesborough,	6	210
FALL RIVER,	197	176	Hudson,	20	240
Dudley,	11	177	Carver,	6	259
Washington,	2	182	Paxton,	4	304
Brimfield,	5	186	HOLYOKE,	164	328
CHICOPEE,	48	191	Middlefield,	6	417
South Hadley,	15	191	Gay Head,	2	559

SCARLET-FEVER.

The statistics relating to the mortality from scarlet-fever presented in this paper are compiled from a total of 14,639 deaths which occurred in Massachusetts in the twenty-year period (1871–90). The deaths from this cause constituted 2.04 per cent. of the total mortality for the same period.

The following table presents the mortality per 10,000 of the population from this cause for each year of the period under consideration: —

Annual Death Rates from Scarlet-fever per 10,000 of the Population. Massachusetts (1871-90).

YEARS.	Mortality Rates from Scarlet-fever.	YEARS.	Mortality Rates from Scarlet-fever.
1871,	5.8	1881,	2.2
1872,	8.9	1882,	1.7
1873,	6.4	1883,	3.5
1874,	8.6	1884,	3.3
1875,	10.2	1885,	3.0
1876,	7.4	1886,	1.7
1877,	2.8	1887,	2.9
1878,	2.4	1888,	2.5
1879,	4.9	1889,	.8
1880,	3.2	1890,	.9
Average, ten years, 1871-80,	6.2	Average, ten years, 1881-90,	2.2
Annual average, twenty years,			4.1

Comparing the two decades, 1871–80 with 1881–90, it appears that there was a great decrease in the mortality from scarlet-fever from the first period to the second.

Distribution by Counties.

The ratios of mortality from scarlet-fever by counties for the period (1871–90) were as follows: —

COUNTIES.	Deaths from Scarlet-fever, 1871-90.	Death Rates from Scarlet-fever	
		Per 10,000 of the Population.	Per 10,000 of Children under 10.
Barnstable,	117	1.83	10.6
Berkshire,	500	3.62	16.8
Bristol,	1,239	4.45	22.2
Dukes,	11	1.28	9.8
Essex,	1,746	3.57	19.0
Franklin,	142	1.97	10.2
Hampden,	887	4.26	20.8
Hampshire,	298	3.15	16.8
Middlesex,	2,690	4.23	21.3
Nantucket,	5	.67	5.0
Norfolk,	730	3.78	19.4
Plymouth,	397	2.68	15.2
Suffolk,	3,867	4.98	27.0
Worcester,	2,010	4.48	21.3
THE STATE,	14,639	4.10	20.8

In examining the statistics of mortality from this cause with reference to their relation to density of population, the following table may be consulted: —

Counties of Massachusetts arranged according to their Death Rates from Scarlet-fever (1871–90), that of the State being taken as 100, the Density of Population being expressed in Acres to Each Person.

COUNTIES.	Density of Population. Acres to Each Person (Census of 1880).	Mortality Rank from Scarlet-fever, that of the State = 100.	
		Mortality Rank, Total Population.	Mortality Rank, Children under 10.
Nantucket,	11.2	16	26
Dukes,	18.4	31	50
Barnstable,	7.5	45	53
Franklin,	11.8	48	50
Plymouth,	5.9	65	76
Hampshire,	7.7	77	85
Essex,	1.3	87	92
Berkshire,	8.9	88	71
Norfolk,	3.3	92	95
THE STATE,	2.9	100	100
Middlesex,	1.7	103	101
Hampden,	3.9	104	101+
Worcester,	4.4	108	103
Bristol,	2.5	109	104
Suffolk,	.07	121	120

Pursuing this line of inquiry still further, the following table presents the counties in three groups, arranged with reference to their density: —

Counties arranged according to their Density of Population.	Counties.	Acres to Each Person.	Mortality Rank from Scarlet-fever, the State =100.
I. County in which there is less than one acre to each person living,	Suffolk,	.07	121
II. Counties having more than one acre but less than four acres to each person,	Essex,	1.3	87
	Middlesex,	1.7	103
	Bristol,	2.5	109
	Norfolk,	3.3	92
	Hampden,	3.9	104
		Average, 2.2.	Average, 99.
III. Counties having more than four acres to each person living,	Worcester,	4.4	108
	Plymouth,	5.9	65
	Hampshire,	7.7	77
	Berkshire,	8.9	88
	Barnstable, Dukes and Nantucket,	9.0	41
	Franklin,	11.8	48
		Average, 6.4.	Average, 71.
THE STATE,		2.9	100

The mortality from scarlet-fever therefore was as follows: —

In *dense* districts,	1,000
In *medium* districts,	818
In *sparse* districts,	587

The exceptional instances are the following: Bristol, in which the high mortality rate from this cause appears to be due to the effect of a large number of deaths in its principal city, — Fall River. This is, however, partially balanced by a low death rate from the same cause in Taunton and New Bedford. Middlesex, several of whose large cities are contiguous to the metropolitan district of Suffolk County, has a higher rank than the average. Hampden suffers in consequence of the high position of Holyoke and Springfield in the scale, which had three-fifths of all the deaths from scarlet-fever in the county. Worcester County maintains a high ratio, as compared with the average of its group. While Barnstable, Dukes and Nantucket have low positions, which are in direct ratio to their inaccessibility and distance from large centres of population, Franklin County, which also has a low position, is sparsely settled, and has but four towns whose population is more than 2,000 in each.

Reference to the map shows very plainly certain regions which appear to have had a high mortality rate from scarlet-fever. These are the metropolitan district of Suffolk County and its immediate neighborhood in Middlesex County, the southern central portion of Worcester County, the region at the junction of Worcester, Middlesex and Norfolk counties, the central portion of Hampden County and the north-east part of Essex.

Classification by Towns.

The list of towns is prepared upon the same plan with those for the other diseases.

The towns are divided into five classes, in accordance with their ratios of mortality from scarlet-fever, those having the least mortality being placed at the top of the list.

The following fifteen towns had no deaths from scarlet-fever during the twenty years. (See Map No. 2.) An examination of the characteristics of these towns may afford light upon the causes of their exemption. The towns were Alford, Egremont, Tyringham, Mt. Washington, Plainfield, Monroe, Greenwich, Phillipston, Paxton, Northborough, Dunstable, Tyngsborough, Gos-

nold, Edgartown and Gay Head. The entire population of these fifteen towns in 1880 was but 8,815, and in 1890 it was less. Only two of them had over 1,000 inhabitants. Eleven of the number were not upon any railway lines. In all of them the ratio of children under ten years of age (the susceptible age for scarlet-fever) was small, as compared with that of the State.

Alford, Egremont and Mt. Washington are small contiguous towns upon the south-west border of the State. Plainfield is in the centre of a sparsely settled region, surrounded by small towns, all of which had very low ratios of mortality from this cause. Dunstable and Tyngsborough are two small contiguous towns in northern Middlesex County.

In the foregoing tables of counties the death rates have been calculated both for the total population and for the children under ten years. In the list of cities and towns the death rates are calculated only upon the total population.

It is probable that the susceptible portion of the population in such towns (the children) has less communication with the people of neighboring towns than the adult population, and also less than those of larger towns in which facilities of intercommunication are greater.

Gay Head, Edgartown and Gosnold were the three most remote and inaccessible towns of Dukes County.

The towns having populations of more than 4,000 each which maintained a low mortality rate from scarlet-fever for the twenty years were Easton, Orange, Provincetown, Revere, Barnstable, Amherst, Bridgewater, Middleborough, Canton, Melrose, Concord, Palmer and Warren.

There are no cities in that portion of the list containing places having a mortality rate which was more than fifty per cent. below that of the State.

The city having the lowest mortality rate from this cause during the period was Taunton, which had a rank of 53, as compared with the State (100). The cities having the next higher ratios were Brockton, 55; Malden, 65; Northampton, 68; Waltham, 70; New Bedford, 73; and Haverhill, 73.

The rank of Lowell, which had a comparatively high mortality rate for some of the other infectious diseases, was but 81 in its mortality for scarlet-fever.

At the other extreme were Arlington, with a rank of 282;

Dudley, 239; North Brookfield, 224; Webster, 216; Ware, 214; Maynard, 207; Fall River, 185; Lee, 183; New Braintree, 180; Acton, 162; Lanesborough, 161; Belmont, 158; Norfolk, 157; and Boylston, 157.

Fall River is the only city having an excessively high death rate from this cause, the number of deaths from scarlet-fever during the period in question being 765. Dudley, West Brookfield, Webster, Ware and Lee are manufacturing towns, all having high death rates from this cause.

It is worthy of note that in this list of towns having extremely high ratios Dudley and Webster are contiguous, and Southbridge, which also had a comparatively high rank (119), joins one of them. Belmont and Arlington also join, and are in close proximity to the metropolitan county of Suffolk. Acton and Maynard are also contiguous, and so also are Ware, North Brookfield and New Braintree. Woburn, with a comparatively high rank, joins Arlington, and Clinton (149) and Boylston (157) are contiguous.

The cities having comparatively high positions in the mortality list from scarlet-fever were (after Fall River, already mentioned): Woburn, 149; Marlborough, 133; Somerville, 131; Boston, 128; Holyoke, 121; Cambridge, 117; Pittsfield, 116; Newburyport, 114; Worcester, 111; Springfield, 110; Chelsea, 110; and Lawrence, 110.

In the 87 densely settled towns (see page 763) the mortality from scarlet-fever had an annual ratio of 4.31 per 10,000; in the 259 sparsely settled towns the mortality was 2.80 per 10,000; or, in other words, the mortality was as 1,000 in the former to 650 in the latter.

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100.

Towns in which there were no deaths from scarlet-fever during the twenty years: Alford, Egremont, Tyringham, Mount Washington, Plainfield, Monroe, Greenwich, Phillipston, Paxton, Northborough, Dunstable, Tyngsborough, Gosnold, Edgartown and Gay Head.

Cities and towns in which the mortality from scarlet fever was more than fifty per cent. below the average: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
New Marlborough, . .	1	6	Richmond, ...	1	11
Hanson, ...	1	9	Ashfield, ...	1	11
Harvard, ...	1	10	Stow, ...	1	11

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100 — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Wales,	1	12	Leverett,	2	33
Bernardston,	1	13	Hardwick,	6	33
Marshfield,	2	14	Sandisfield,	3	33
Cummington,	1	14	Duxbury,	6	33
Boxford,	1	15	Lunenburg,	3	33
Northfield,	2	15	Revere,	8	34
Nantucket,	1	16	Westford,	6	34
Otis,	1	16	Barnstable,	12	34
Granby,	1	16	Enfield,	3	34
Gill,	1	17	Carver,	3	35
Warwick,	1	17	Mattapoisett,	4	36
Lynnfield,	1	18	Lakeville,	3	36
Plympton,	1	18	Essex,	5	36
Ashburnham,	3	18	Amherst,	13	37
Easton,	6	19	Goshen,	1	37
Pelham,	1	20	Bridgewater,	11	37
Falmouth,	4	20	Boxborough,	1	38
Hampden,	1	21	Orleans,	4	38
Petersham,	2	22	Marion,	3	38
Shutesbury,	1	23	Tewksbury,	7	39
Orange,	6	23	Ayer,	6	39
Rochester,	2	23	Hamilton,	3	39
Sturbridge,	4	24	Yarmouth,	7	39
Ludlow,	3	24	Groton,	6	39
Leyden,	1	24	Montgomery,	1	40
Rowe,	1	24	Holland,	1	40
Wellesley,	3	24	Norwell,	6	40
Chilmark,	1	25	Bolton,	3	40
Provincetown,	9	25	Rowley,	4	40
Hull,	1	25	Brimfield,	4	40
Sherborn,	3	26	North Reading,	3	40
Wilmington,	2	26	Hawley,	2	41
Wendell,	1	26	Sudbury,	4	41
Bradford,	6	26	Berkley,	3	42
Prescott,	1	26	Oakham,	3	42
Lincoln,	2	27	Mansfield,	10	43
Chatham,	5	27	Raynham,	6	43
Cottage City,	1	27	Groveland,	8	44
Wenham,	2	27	West Bridgewater,	6	44
Norton,	4	28	Hadley,	7	44
Winthrop,	3	29	Middleborough,	19	44
Manchester,	4	30	Princeton,	4	44
Reading,	8	30	Mendon,	4	44
Billerica,	5	30	Shelburne,	6	45
Townsend,	5	31	Florida,	5	46
Sunderland,	2	32	Wellfleet,	7	46
Becket,	3	32	Canton,	17	46
Williamsburg,	6	33	Freetown,	5	46

Dudley, 239; North Brookfield, 224; Webster, 216; Ware, 214; Maynard, 207; Fall River, 185; Lee, 183; New Braintree, 180; Acton, 162; Lanesborough, 161; Belmont, 158; Norfolk, 157; and Boylston, 157.

Fall River is the only city having an excessively high death rate from this cause, the number of deaths from scarlet-fever during the period in question being 765. Dudley, West Brookfield, Webster, Ware and Lee are manufacturing towns, all having high death rates from this cause.

It is worthy of note that in this list of towns having extremely high ratios Dudley and Webster are contiguous, and Southbridge, which also had a comparatively high rank (119), joins one of them. Belmont and Arlington also join, and are in close proximity to the metropolitan county of Suffolk. Acton and Maynard are also contiguous, and so also are Ware, North Brookfield and New Braintree. Woburn, with a comparatively high rank, joins Arlington, and Clinton (149) and Boylston (157) are contiguous.

The cities having comparatively high positions in the mortality list from scarlet-fever were (after Fall River, already mentioned): Woburn, 149; Marlborough, 133; Somerville, 131; Boston, 128; Holyoke, 121; Cambridge, 117; Pittsfield, 116; Newburyport, 114; Worcester, 111; Springfield, 110; Chelsea, 110; and Lawrence, 110.

In the 87 densely settled towns (see page 763) the mortality from scarlet-fever had an annual ratio of 4.31 per 10,000; in the 259 sparsely settled towns the mortality was 2.80 per 10,000; or, in other words, the mortality was as 1,000 in the former to 650 in the latter.

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100.

Towns in which there were no deaths from scarlet-fever during the twenty years: Alford, Egremont, Tyringham, Mount Washington, Plainfield, Monroe, Greenwich, Phillipston, Paxton, Northborough, Dunstable, Tyngsborough, Gosnold, Edgartown and Gay Head.

Cities and towns in which the mortality from scarlet fever was more than fifty per cent. below the average: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
New Marlborough, . .	1	6	Richmond, ...	1	11
Hanson, ...	1	9	Ashfield, ...	1	11
Harvard, ...	1	10	Stow, ...	1	11

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100 — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Wales,	1	12	Leverett,	2	33
Bernardston,	1	13	Hardwick,	6	33
Marshfield,	2	14	Sandisfield,	3	33
Cummington,	1	14	Duxbury,	6	33
Boxford,	1	15	Lunenburg,	3	33
Northfield,	2	15	Revere,	8	34
Nantucket,	1	16	Westford,	6	34
Otis,	1	16	Barnstable,	12	34
Granby,	1	16	Enfield,	3	34
Gill,	1	17	Carver,	3	35
Warwick,	1	17	Mattapoisett,	4	36
Lynnfield,	1	18	Lakeville,	3	36
Plympton,	1	18	Essex,	5	36
Ashburnham,	3	18	Amherst,	13	37
Easton,	6	19	Goshen,	1	37
Pelham,	1	20	Bridgewater,	11	37
Falmouth,	4	20	Boxborough,	1	38
Hampden,	1	21	Orleans,	4	38
Petersham,	2	22	Marion,	3	38
Shutesbury,	1	23	Tewksbury,	7	39
Orange,	6	23	Ayer,	6	39
Rochester,	2	23	Hamilton,	3	39
Sturbridge,	4	24	Yarmouth,	7	39
Ludlow,	3	24	Groton,	6	39
Leyden,	1	24	Montgomery,	1	40
Rowe,	1	24	Holland,	1	40
Wellesley,	3	24	Norwell,	6	40
Chilmark,	1	25	Bolton,	3	40
Provincetown,	9	25	Rowley,	4	40
Hull,	1	25	Brimfield,	4	40
Sherborn,	3	26	North Reading,	3	40
Wilmington,	2	26	Hawley,	2	41
Wendell,	1	26	Sudbury,	4	41
Bradford,	6	26	Berkley,	3	42
Prescott,	1	26	Oakham,	3	42
Lincoln,	2	27	Mansfield,	10	43
Chatham,	5	27	Raynham,	6	43
Cottage City,	1	27	Groveland,	8	44
Wenham,	2	27	West Bridgewater,	6	44
Norton,	4	28	Hadley,	7	44
Winthrop,	3	29	Middleborough,	19	44
Manchester,	4	30	Princeton,	4	44
Reading,	8	30	Mendon,	4	44
Billerica,	5	30	Shelburne,	6	45
Townsend,	5	31	Florida,	5	46
Sunderland,	2	32	Wellfleet,	7	46
Becket,	3	32	Canton,	17	46
Williamsburg,	6	33	Freetown,	5	46

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100 — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Melrose,	20	46	Worthington,	8	48
Carlisle,	2	47	Holbrook,	8	48
Concord,	15	47	Conway,	7	48
Chesterfield,	3	47	Hatfield,	6	49
Chelmsford,	10	48	Washington,	2	49
Deerfield,	14	48	Bellingham,	5	50
Palmer,	22	48	Warren,	16	50
Harwich,	13	48	Granville,	5	50
Truro,	4	48			

Cities and towns in which the mortality from scarlet-fever was below the average but not fifty per cent. below it:—

Savoy,	3	51	Blackstone,	25	62
Royalston,	5	51	Blandford,	5	62
Burlington,	3	51	Hingham,	23	62
Rehoboth,	8	51	East Bridgewater,	14	63
Westminster,	7	52	West Stockbridge,	10	63
Belchertown,	10	52	Cheshire,	8	63
Charlemont,	4	52	Wrentham,	13	64
Bedford,	4	52	Tisbury,	8	64
Williamstown,	16	52	MALDEN,	74	65
Dartmouth,	15	53	Great Barrington,	25	65
Dedham,	27	53	Winchendon,	20	65
TAUNTON,	96	53	Sharon,	8	65
Andover,	28	54	Peabody,	48	66
Wareham,	13	55	Milton,	18	67
BROCKTON,	72	55	Ashby,	5	67
Sandwich,	16	55	Weston,	8	67
Greenfield,	19	55	Braintree,	23	67
Dover,	3	56	Merrimac,	9	68
Erving,	4	56	Whately,	6	68
Rockport,	18	56	Dighton,	10	68
Windsor,	3	57	Walpole,	14	68
Templeton,	18	57	NORTHAMPTON,	69	68
Monterey,	3	58	Hubbardston,	8	70
Chester,	7	58	Saugus,	16	70
Methuen,	21	58	Eastham,	4	70
Westport,	14	59	Uxbridge,	18	70
Montague,	22	60	Dennis,	19	70
New Ashford,	1	60	WALTHAM,	74	70
Attleborough,	55	60	Medfield,	8	71
Peru,	2	60	Norwood,	15	72
Adams,	51	61	Whitman,	16	72
Easthampton,	21	61	Shirley,	8	72
Littleton,	5	61	NEW BEDFORD,	178	73
Colrain,	9	62	Topsfield,	7	73

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100 — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
HAVERHILL, . . .	115	73	Westhampton, . .	4	87
Auburn, ...	8	74	North Andover, . .	23	87
Wilbraham, . . .	10	75	Heath, ...	4	87
Nahant, ...	5	75	Georgetown, . . .	16	87
Hancock, ...	4	76	Ashland, . . .	17	87
FITCHBURG, . . .	92	76	Athol, ...	38	87
GLOUCESTER, . . .	123	77	Berlin, ...	7	87
Dalton, ...	13	77	Lexington, . . .	19	88
Stoneham, . . .	31	77	Kingston, . . .	11	88
Pepperell, . . .	15	77	Gardner, . . .	40	88
Pembroke, . . .	9	78	Charlton, . . .	14	90
Holden, ...	16	78	Halifax, ...	4	90
Wakefield, . . .	36	78	Longmeadow, . .	12	91
Lancaster, . . .	13	79	Foxborough, . . .	22	91
Everett, ...	35	79	Ipswich, ...	28	92
Framingham, . . .	44	79	Stoughton, . . .	37	92
LYNN, ...	262	79	SALEM, ...	208	93
QUINCY, ...	73	79	Westborough, . .	40	93
CHICOPEE, . . .	74	80	Newbury, . . .	12	93
Fairhaven, . . .	19	80	North Adams, . .	65	94
Natick, ...	56	80	West Brookfield, . .	15	95
Swanzey, ...	9	81	Weymouth, . . .	83	96
Monson, ...	25	81	Hanover, . . .	15	96
Southampton, . . .	7	81	Plymouth, . . .	57	98
LOWELL, ...	385	81	Douglas, ...	18	98
Stockbridge, . . .	16	83	Leominster, . . .	44	98
NEWTON, ...	122	83	Salisbury, . . .	33	98
Medford, ...	55	84	Southwick, . . .	9	99
Clarksburg, . . .	5	84	Sheffield, . . .	18	99
Upton, ...	14	84	South Hadley, . .	29	99
Grafton, ...	28	85	THE STATE, . .	14,639	100
Marblehead, . . .	52	85			
Middleton, . . .	7	85			

Cities and towns in which the mortality from scarlet-fever was above the average but not fifty per cent. above it: —

Somerset, ...	17	103	Oxford, ...	23	107
Danvers, ...	56	103	Tolland, ...	4	108
Russell, ...	7	104	Beverly, ...	75	108
Rockland, . . .	34	105	Southborough, . .	19	108
Buckland, . . .	15	105	Needham, . . .	34	109
Mashpee, ...	3	106	Abington, . . .	33	109
Wayland, ...	17	106	Winchester, . . .	34	109
Lenox, ...	19	106	LAWRENCE, . . .	336	110
Brewster, ...	10	107	CHELSEA, . . .	207	110
Hinsdale, ...	14	107	Sutton, ...	28	110
Swampscott, . . .	22	107	West Boylston, . .	27	110

Cities and Towns arranged in the Order of their Death Rates from Scarlet-fever, the State being taken as 100 — Concluded.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
SPRINGFIELD,	312	110	Hopkinton,	47	125
WORCESTER,	548	111	BOSTON,	3,767	128
Amesbury,	47	111	Cohasset,	23	128
West Springfield,	38	112	Sterling,	15	129
Randolph,	37	112	SOMERVILLE,	282	131
Brookfield,	26	112	Middlefield,	7	132
Hyde Park,	73	113	Dana,	8	132
NEWBURYPORT,	127	114	MARLBOROUGH,	113	133
Franklin,	38	114	Shrewsbury,	17	138
Agawam,	21	115	Scituate,	28	138
PITTSFIELD,	130	116	Spencer,	85	139
CAMBRIDGE,	519	117	Seekonk,	14	139
Holliston,	30	118	West Newbury,	23	141
Huntington,	12	118	Millbury,	56	144
Southbridge,	63	119	Watertown,	67	145
Brookline,	84	120	Westfield,	100	147
Medway,	39	120	Northbridge,	49	147
Hudson,	37	120	Leicester,	34	149
HOLYOKE,	223	121	WOBURN,	133	149
Barre,	24	121	Clinton,	97	149
Milford,	93	122	Rutland,	13	150
Dracut,	16	122			

Cities and towns in which the mortality from scarlet-fever was more than fifty per cent. above the average: —

Boylston,	11	157	FALL RIVER,	765	185
Norfolk,	12	157	Maynard,	39	207
Belmont,	21	158	Ware,	93	214
Lanesborough,	17	161	Webster,	101	216
Acton,	24	162	North Brookfield,	82	224
New Braintree,	9	180	Dudley,	55	239
Lee,	59	183	Arlington,	95	282

DIPHTHERIA AND CROUP.

The term diphtheria does not appear in the registration reports of the State until 1858, a fact which has but little bearing upon the question of its prevalence at an earlier period.

From 1858 the annual number of deaths assigned to these causes rapidly increased until 1863, when 1,420 deaths from diphtheria and croup were reported, and 1,231 in 1864. There was then a rapid decline till 1867, when there were but 251 deaths registered from diphtheria and croup, and the annual number continued at quite a uniform rate of about 275 deaths for the

next seven years, when it rose again to 2,610 in 1876 and 2,734 in 1877.

The diphtheria death rate does not coincide with the general death rate, except in the period 1862 to 1867; but in 1872, when the general mortality rate was at its highest point, and infectious diseases were generally very prevalent, the diphtheria death rate was far below the mean, and in 1876 and 1877, when the general death rate was quite near the mean, the diphtheria death rate was at its highest point.

In this paper it is to be understood that the data given include *fatal croup*, since it is generally conceded by the physicians of Massachusetts that fatal croup, so far as the registration returns are concerned, cannot well be separated from diphtheria.

The number of registered deaths from diphtheria and croup in Massachusetts during the twenty years (1871–90) was 36,553, or 5.1 per cent. of the mortality from all causes for the same period. It was also equivalent to an annual mortality rate of 10 per 10,000 of the living population.

The annual mortality attributed to diphtheria and croup for each year of the period was as follows, per 10,000 of the population: —

YEAR.	Mortality Rate.	YEAR.	Mortality Rate.
1871, ...	5.0	1881, ...	12.6
1872, ...	4.9	1882, ...	9.5
1873, ...	4.7	1883, ...	8.6
1874, ...	5.6	1884, ...	8.5
1875, ...	11.4	1885, ...	7.8
1876, ...	19.9	1886, ...	7.9
1877, ...	19.1	1887, ...	8.1
1878, ...	15.0	1888, ...	9.0
1879, ...	13.4	1889, ...	10.2
1880, ...	13.5	1890, ...	7.3
Average, ten years (1871-80),	11.4	Average, ten years (1881-90),	8.9
Average, twenty years (1871-90), ...			10.01.

Distribution by Counties.

In the following table are presented the number of deaths from diphtheria and croup in each county for the twenty-year period (1871–90), with the mortality rate per 10,000 of the population in each: —

COUNTIES.	Deaths from Diphtheria and Croup.	Death Rate in Each, per 10,000 of the Population.	Death Rate in Each, per 10,000 of Children under 10.
Barnstable,	356	5.6	32.2
Berkshire,	1,551	11.2	52.3
Bristol,	2,546	9.1	45.6
Dukes,	13	1.5	11.6
Essex,	5,235	10.7	57.0
Franklin,	439	6.1	31.5
Hampden,	2,437	11.7	57.2
Hampshire,	758	8.0	42.8
Middlesex,	6,445	10.1	51.0
Nantucket,	113	15.1	114.0
Norfolk,	1,670	8.6	44.4
Plymouth,	1,108	7.5	42.4
Suffolk,	10,078	13.0	70.5
Worcester,	3,804	8.4	40.3
THE STATE,	36,553	10.01	52.1

By this table it appears that the highest ratios were in Nantucket, Suffolk, Hampden and Berkshire, and the lowest in Dukes, Barnstable, Franklin and Plymouth.

In the following table the counties are arranged according to their mortality rates from diphtheria and croup, the density in acres per person being also given : —

Counties arranged according to their Mortality Rates from Diphtheria and Croup (1871-90), that of the State being taken as 100, with the Density expressed in Acres per Inhabitant.

COUNTIES.	Density of Population, Acres per Inhabitant. 1880.	Mortality Rank for Diphtheria and Croup, the State – 100.	Mortality Rank as compared with Children under 10 Years.
Dukes,	18.4	15	22
Barnstable,	7.5	54	62
Franklin,	11.8	59	61
Plymouth,	5.9	73	81
Hampshire,	7.7	78	82
Worcester,	4.4	82	77
Norfolk,	3.3	84	85
Bristol,	2.5	89	87
Middlesex,	1.7	99	98
THE STATE,	2.9	100	100
Essex,	1.3	104	109
Berkshire,	8.9	109	101
Hampden,	3.9	114	110
Suffolk,	.07	127	135
Nantucket,	11.2	147	219

In the following table the counties are arranged in three groups, according to their density of population:—

Counties grouped according to their Density of Population.	Counties.	Acres to each Person, 1880.		Mortality Rank from Diphtheria and Croup.	
I. County in which there is less than one acre to each person,	Suffolk,	.07		127	
II. Counties having more than one acre but less than four acres to each person,	Essex,	1.3	Average, 2.1.	104	Average, 99.
	Middlesex,	1.7		99	
	Bristol,	2.5		89	
	Norfolk,	3.3		84	
	Hampden,	3.9		114	
III. Counties having more than four acres to each person,	Worcester,	4.4	Average, 6.4.	82	Average, 80.
	Plymouth,	5.9		73	
	Hampshire,	7.7		78	
	Berkshire,	8.9		109	
	Barnstable, Dukes and Nantucket,	9.0		59	
	Franklin,	11.8		59	

In the densely settled district, having but $\frac{7}{100}$ of an acre to each person, the average annual mortality rate from diphtheria and croup was 13 per 10,000 of the population.

In the medium districts, in which the average density was 2.1 acres to each person, the mortality rate was 10.1 per 10,000.

In the sparsely settled districts, in which the average density was 6.4 acres to each person, the mortality rate was 8.2 per 10,000 annually.

Assuming the mortality of the dense districts as 1,000, we have the following results:—

Mortality from diphtheria and croup in *dense* districts,	1,000
Mortality from diphtheria and croup in *medium* districts,	780
Mortality from diphtheria and croup in *sparse* districts,	634

While these figures present a result which differs from the statistics of England and Wales, it should be remembered that they are compiled from a population less than one-tenth as large, and are, therefore, less trustworthy as sources from which conclusions are to be drawn.

In another point, however, the conclusions agree with those of Dr. Longstaff, and that is, that in the second half of the period the towns suffered, relatively, more than in the first half.

In 18 out of the 28 cities the mortality rate from diphtheria and croup had materially increased from the first to the second half of the period of twenty years under consideration, and these 18 included the 6 largest cities in the State.

The districts which suffered most severely, taking the whole period of twenty years, were the northern half of Berkshire County, that portion of the valley of the Connecticut River within the State which lies in Hampshire and Hampden counties, the valleys of the Westfield and Chicopee rivers with the tributary valleys of the latter, the southern half of Worcester County, the metropolitan district about Boston, the Merrimack River valley, the southern sea-coast region of Essex County, the eastern part of Norfolk County, the eastern border of Bristol County, the north-west corner of Plymouth County and the town of Nantucket.

Those regions which had the greatest immunity were the southern half of Berkshire County, the whole of Franklin County, the east and west parts of Hampshire County, the west part of Hampden County, the northern half of Worcester County, the north and west part of Middlesex, the north-east sea-coast district of Essex, the west half of Norfolk, the western border of Bristol, nearly all of Plymouth and the whole of Barnstable and Dukes counties.

In comparing the distribution of fatal diphtheria and croup in the State with that of other diseases, certain other similar inquiries relating to the other principal infectious diseases tend to show that diphtheria is "not regulated by the same causes as influence the general mortality," except that, so far as the density of population is concerned, the results of observations in Massachusetts lead us to an opposite conclusion from that which is derived from the statistics of England and Wales.

In the course of personal inspections made in many parts of the State, in city, town and country districts, my observations tend to support the second paragraph of the following statement found in the report already quoted, with reference to the

increased facilities offered in the country districts for the spread of diphtheria.

"If we grant for a moment the exciting cause of the disease to have its origin in the country, it is just possible that the constantly increasing communication between town and country, by affording additional opportunities of importing the disease, might account for its increased prevalence in towns.

"Although the greater proximity of people in towns would, at first sight, seem to increase greatly the chances of infection, it is by no means certain that the individuals of a town community come so much into personal contact as the dwellers in a lonely hamlet. There may be but few opportunities for the introduction of the poison into an isolated village, but once introduced, there are great facilities for its spread. In a village every one knows his neighbors, whereas in a large town dwellers in the same street are often complete strangers to each other."

Classification by Towns.

Of the 20 towns which stand at the foot of the list as having excessive mortality rates from diphtheria and croup in the period under consideration, 5 are small, or comparatively small, and contiguous towns in the north-west corner of the State. (See Map No. 3.)

These towns are mainly inhabited by a sparsely settled farming population, and their average level above the sea is much higher than that of the State in general. The lowest land in this district is at least five hundred feet above the sea, and the average level of the district is not far from twelve hundred feet above the sea level. The district is very thickly wooded with forests of oak, pine, maple and other woods, except in the valleys, which have a comparatively small area of cultivated meadows and low land. One small river flows through it in a general north-westerly direction, receiving many rapid mountain brooks as tributaries. There is one manufacturing town (North Adams), a railroad centre, of 15,000 inhabitants.

Hancock is a town of small population, remote from railway communication. It forms a part of the western border of the State, and lies along the Taconic ridge of hills. Its land is elevated, the principal village being 1,100 feet above the sea.

Adams is a manufacturing town, having several villages upon the south branch of the Hoosac River, lying chiefly in a valley between two high mountain ridges.

Florida is a hilly town of small population (459 in 1880). The Fitchburg Railroad passes under the town, from its eastern to its western border, a distance of five miles, by means of the Hoosac Tunnel. Its population, which was 1,322 by the census of 1870, was rapidly diminished after the completion of the tunnel to 572 in 1875 and 459 in 1880.

Freetown is a town of small population (1,329 in 1880), in Bristol County, adjoining the manufacturing city of Fall River. The land is low and sandy.

Webster is a manufacturing town in Worcester County, on comparatively low land.

Spencer is a manufacturing town, with a relatively dense population, situated upon a high hill in Worcester County. The chief industry is shoe manufacture.

Turning now to the other extreme, two towns had no deaths from diphtheria during the period under consideration. Both of these are small towns. Their chief characteristic is *inaccessibility*. Neither of them is upon or near a railway line, and public travel through them is very limited. Cummington is in the western part of Hampshire County, and remote from communication with other towns. Chilmark is a remote town upon the island of Martha's Vineyard, at a distance from the points of summer resort.

All of the 20 towns having very low diphtheria death rates are towns of small population, sparsely inhabited, with no dense villages or manufacturing districts. Chilmark, Tisbury and Edgartown are contiguous towns, upon the island of Martha's Vineyard. Lincoln, Littleton, Bolton, Harvard, Berlin and Tyngsborough are farming towns, partly contiguous, in north-western Middlesex and north-eastern Worcester counties. Plainfield, Worthington, Goshen and Cummington are also small agricultural towns in western Hampshire County.

The average annual death rate from diphtheria and croup in the 87 densely settled towns and cities was 10.92 per 10,000 of the population, while that of the 259 rural or sparsely settled towns was 6.54 per 10,000 for the same period.

The relation of certain railway lines to the diphtheria death

rate is worthy of note. There were, during the period in question, about two thousand miles of railway in operation in the State. Many of the towns of small size are at a considerable distance from these railways, or are of so little importance that very few stations are located in such towns.

The Boston & Albany Railroad, the principal line from the seaport of Boston through the State to the West, carries a very large number of passengers each year, and has one or more stations in nearly every town through which it passes. The greater number of cities and towns through which this railway passes, in its course of one hundred and fifty miles, had comparatively high diphtheria death rates. Those upon the line of the Fitchburg Railroad, another line of similar length, but having much less traffic, had lower diphtheria death rates; while those upon the Massachusetts Central, a line of about one hundred miles in length, also running east and west, but of comparatively recent construction, had, in general, still lower death rates from the same cause.

It is also worthy of note that, out of the 28 cities, 18, including all the most populous except Fall River, had a death rate from diphtheria and croup higher than the average of the State, and of these 17 were in the group having from 0 to 50 per cent. higher rates than the average of the State. The remaining city, Holyoke, which had a diphtheria death rate of 15.38 per 10,000 per year for the period, is a thriving city of rapid growth (population, 1850, 3,245; 1890, 35,528), the principal industry of which is the manufacture of paper. It has a population in which the Canadian French form a very considerable fraction.

The metropolitan district, comprised in the city of Boston and the contiguous cities and towns of Cambridge, Somerville, Malden, Chelsea, Everett, Quincy, Lynn and Brookline, constituting a comparatively densely populated and rapidly increasing district, had a mortality rate from diphtheria and croup which was quite uniform and considerably above the average of the State, being very nearly 12.5 per 10,000 annually, the exception being Brookline, with a mortality rate from these causes of 8.9 per 10,000. That of Newton, a little further out, was 7.2; and that of Woburn, 10 miles, was 6.1.

The following list presents the comparative position of the cities, with reference to their mortality from diphtheria and croup, the State being taken as 100: —

Woburn,	55	Chelsea,	108
Fitchburg,	70	Chicopee,	108
Marlborough,	72	Springfield,	112
Newton,	73	Somerville,	113
Newburyport,	76	Pittsfield,	114
Fall River,	88	Salem,	115
Northampton,	90	Cambridge,	116
Waltham,	92	Lowell,	125
Taunton,	95	Boston,	131
Worcester,	95	Haverhill,	131
Malden,	102	Brockton,	132
New Bedford,	103	Quincy,	132
Gloucester,	107	Lawrence,	135
Lynn,	107	Holyoke,	151

Diphtheria and Croup.

Towns in which there were no deaths from diphtheria and croup during the period 1871-90: Cummington and Chilmark.

Cities and towns in which the mortality from diphtheria and croup was more than fifty per cent. below the average of the State: —

	Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State = 100.		Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State = 100.
Lincoln,	1	5	Sunderland,	3	19
Hampden,	1	8	Wrentham,	10	20
Tisbury,	3	10	Sheffield,	9	20
Littleton,	2	10	Warwick,	3	20
Berlin,	2	10	Ashby,	4	21
Plainfield,	1	11	Dunstable,	2	21
Bolton,	2	11	Middlefield,	3	22
Wenham,	2	11	Mt. Washington,	1	24
New Salem,	2	11	New Ashford,	1	24
Harvard,	3	12	New Braintree,	3	24
Worthington,	2	13	Provincetown,	22	25
Charlton,	5	13	Otis,	4	25
Dana,	2	13	Topsfield,	6	26
Norton,	5	14	Bernardston,	5	26
Goshen,	1	15	Barre,	13	26
Tyngsborough,	2	15	Barnstable,	23	26
Edgartown,	5	18	Gill,	4	26
Southwick,	4	18	Lunenburg,	6	26
Halifax,	2	18	Acton,	10	27
Ashfield,	4	18	Rutland,	6	28
Marshfield,	7	19	Sherborn,	8	28

Diphtheria and Croup — Continued.

	Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.		Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.
Hubbardston,	8	28	Leyden,	4	38
Eastham,	4	28	Stockbridge,	19	39
Rehoboth,	11	28	Franklin,	33	40
Rowley,	7	28	Orange,	26	40
Lakeville,	6	29	Weston,	12	40
Billerica,	12	29	Winchendon,	31	41
Dover,	4	30	Marion,	8	41
Dighton,	11	30	Essex,	14	41
Nahant,	5	30	Middleborough,	44	41
Leominster,	34	30	Paxton,	5	41
Gay Head,	1	30	Shelburne,	14	42
Boxborough,	2	30	Wellesley,	13	42
Petersham,	7	31	Alford,	3	42
Phillipston,	4	31	Mashpee,	3	42
Chesterfield,	5	32	Lynnfield,	6	43
Pelham,	4	32	Ashburnham,	18	43
Prescott,	3	32	Wendell,	4	43
Medfield,	9	32	Tolland,	4	43
Mattapoisett,	9	32	Swanzey,	12	43
Kingston,	10	32	Richmond,	10	43
Gosnold,	1	32	Westport,	26	44
Holland,	2	32	New Marlborough,	17	44
Cottage City,	3	32	Lexington,	24	44
Westminster,	11	32	Granville,	11	44
Amherst,	29	33	Townsend,	18	45
Hawley,	4	33	Foxborough,	27	45
Great Barrington,	32	33	Sterling,	13	45
Upton,	14	34	Scituate,	23	45
Newbury,	11	34	Norwell,	17	45
Boylston,	6	34	Southborough,	20	46
Chelmsford,	18	34	Melrose,	50	46
Burlington,	5	34	Mansfield,	27	46
Blandford,	7	35	Raynham,	16	46
Holden,	18	35	Chester,	14	46
West Bridgewater,	12	35	Rochester,	10	47
Whately,	8	36	Deerfield,	34	47
Westford,	16	36	Norfolk,	9	47
Lancaster,	15	36	Sturbridge,	20	47
Auburn,	10	37	Ipswich,	36	47
Sandwich,	27	37	Athol,	45	48
Concord,	30	37	Hanover,	19	49
Stow,	8	37	Wellfleet,	19	49
Duxbury,	17	38	Clinton,	60	49
Northborough,	13	38	Hudson,	38	49
Pembroke,	11	38	Sudbury,	12	50
Truro,	8	38	Shirley,	14	50
Brewster,	9	38			

Diphtheria and Croup — Continued.

Cities and towns in which the mortality from diphtheria and croup was below the average but not fifty per cent. below it: —

	Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.		Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.
Hull, ...	5	51	Greenfield, . . .	58	67
Medway, ...	42	52	Amesbury, . . .	71	67
Chatham, ...	24	52	Dracut, ...	22	67
Becket, ...	12	52	Georgetown, . . .	31	68
Bedford, ...	10	52	Windsor, . . .	9	68
Leverett, ...	8	53	Hatfield, ...	21	68
Dartmouth, . . .	37	53	West Stockbridge, .	27	68
Medford, ...	87	53	Brimfield, . . .	17	69
Royalston, . . .	13	53	Millbury, . . .	67	69
Belchertown, . . .	26	54	Greenwich, . . .	9	70
Rockland, . . .	44	54	FITCHBURG, . . .	209	70
Bridgewater, . . .	41	55	Revere, ...	41	70
Shrewsbury, . . .	17	55	Beverly, ...	122	70
Shutesbury, . . .	6	55	Wareham, . . .	42	71
Brookfield, . . .	32	55	Wales, ...	15	71
WOBURN, ...	124	55	MARLBOROUGH, . .	152	72
Erving, ...	10	56	Salisbury, . . .	60	72
Manchester, . . .	19	56	Plymouth, . . .	105	72
Hardwick, . . .	26	57	Grafton, ...	60	73
Sandisfield, . . .	13	57	Stoneham, . . .	73	73
Hamilton, . . .	11	57	Cheshire, . . .	23	73
Ludlow, ...	18	58	Wilmington, . . .	14	73
Colrain, ...	21	58	Newton, ...	270	73
Berkley, ...	11	58	Charlemont, . . .	14	74
Sharon, ...	18	59	Weymouth, . . .	101	74
Boxford, ...	10	59	Falmouth, . . .	37	74
Washington, . . .	6	59	Acushnet, . . .	17	75
Reading, ...	39	60	Princeton, . . .	17	75
Walpole, ...	31	61	Belmont, ...	25	75
Templeton, . . .	35	61	North Reading, . .	14	76
Norwood, ...	32	61	Douglas, ...	35	76
Hinsdale, ...	20	61	NEWBURYPORT, . .	212	76
Attleborough, . . .	140	61	Maynard, . . .	36	77
Abington, . . .	47	62	Natick, ...	134	77
Swampscott, . . .	32	62	Dedham, . . .	99	77
Uxbridge, ...	40	63	Granby, ...	12	78
Sutton, ...	40	63	Egremont, . . .	14	78
Longmeadow, . . .	21	63	Westhampton, . .	9	78
Buckland, . . .	23	64	Southampton, . .	17	79
Lenox, ...	29	65	Westfield, . . .	135	80
Winchester, . . .	51	65	Bellingham, . . .	20	80
Bradford, ...	37	65	Brookline, . . .	140	80
Williamsburg, . . .	30	65	Easthampton, . .	69	80
Andover, ...	70	66	Cohasset, . . .	36	80
Leicester, ...	38	67	Oxford, ...	43	81

Diphtheria and Croup — Continued.

	Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.		Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.
Wilbraham,	27	81	Dudley,	51	89
Methuen,	73	81	Milton,	60	90
Stoughton,	81	81	NORTHAMPTON,	225	90
North Brookfield,	74	81	Oakham,	16	90
Winthrop,	21	81	Whitman,	50	90
Fairhaven,	48	81	Orleans,	24	90
Holbrook,	34	82	WALTHAM,	241	92
Harwich,	55	82	Merrimac,	31	93
Westborough,	88	82	Hadley,	37	93
Hingham,	76	83	Carver,	20	94
Needham,	65	83	Arlington,	79	94
Tewksbury,	37	83	Somerset,	39	95
Canton,	77	83	TAUNTON,	426	95
Danvers,	113	83	WORCESTER,	1,174	95
Monterey,	11	84	Montague,	88	96
Peru,	7	85	Heath,	11	96
Rockport,	69	86	Braintree,	82	96
Dennis,	58	86	Milford,	184	96
Wayland,	35	87	Yarmouth,	43	96
Seekonk,	22	87	Framingham,	134	96
Middleton,	18	88	Gardner,	110	97
Dalton,	37	88	West Brookfield,	38	97
FALL RIVER,	910	88	Groton,	37	97
Northfield,	29	88	Ware,	106	97
West Newbury,	36	88	Mendon,	22	98
Blackstone,	89	88	**THE STATE,**	**36,553**	**100**

Cities and towns in which the mortality from diphtheria and croup was above that of the State but not fifty per cent. above it:—

Groveland,	46	101	Conway,	39	108
Saugus,	58	101	CHELSEA,	509	108
Watertown,	117	101	CHICOPEE,	251	108
MALDEN,	292	102	Palmer,	123	109
Holliston,	65	102	SPRINGFIELD,	795	112
Savoy,	15	102	Enfield,	24	112
NEW BEDFORD,	625	103	SOMERVILLE,	613	113
Pepperell,	50	103	PITTSFIELD,	320	114
Carlisle,	11	103	Peabody,	208	115
Warren,	84	105	SALEM,	648	115
Plympton,	15	105	Hyde Park,	168	116
North Adams,	182	105	Ashland,	57	116
West Boylston,	65	106	CAMBRIDGE,	1,288	116
Lanesborough,	28	106	Rowe,	12	117
GLOUCESTER,	428	107	Hanson,	32	119
LYNN,	881	107	Monson,	92	119
Southbridge,	142	107	West Springfield,	102	120
East Bridgewater,	60	108	Monroe,	5	120

Diphtheria and Croup — Concluded.

	Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.		Number of Deaths from Diphtheria and Croup.	Mortality Rank, the State =100.
Lee,	98	121	QUINCY,	303	132
Agawam,	56	123	LAWRENCE,	1,036	135
South Hadley,	90	124	Russell,	23	136
Randolph,	103	125	North Andover,	90	136
LOWELL,	1,483	125	Hopkinton,	129	137
Everett,	142	129	Huntington,	35	138
Montgomery,	8	129	Williamstown,	109	143
Wakefield,	150	130	Easton,	116	145
BOSTON,	9,586	131	Marblehead,	225	147
HAVERHILL,	513	131	Nantucket,	113	147
BROCKTON,	368	132			

Cities and towns in which the mortality from diphtheria and croup was more than fifty per cent. above that of the State: —

HOLYOKE,	692	151	Webster,	196	163
Ayer,	58	151	Freetown,	47	172
Tyringham,	17	153	Florida,	30	187
Clarksburg,	23	155	Adams,	392	189
Northbridge,	129	155	Hancock,	25	190
Spencer,	256	167			

SMALL-POX.

The whole number of deaths from small-pox which were registered in the State for the twenty years (1871–90) was 2,298, which was less than that of any of the other diseases considered in this paper, and these were distributed with much greater irregularity throughout the period than those of any of the other diseases under consideration. Nearly 87 per cent. of the whole number occurred in the epidemic of 1871–73.

The annual mortality from this disease is shown in the following table: —

YEARS.	Mortality Rates per 10,000.	YEARS.	Mortality Rates per 10,000.
1871,	1.9	1881,	.2
1872,	6.7	1882,	.2
1873,	4.3	1883,	.03
1874,	.2	1884,	.01
1875,	.2	1885,	.1
1876,	.2	1886,	-
1877,	.15	1887,	.01
1878,	.01	1888,	.04
1879,	.04	1889,	.03
1880,	.2	1890,	.005
Average, 1871-80,	1.3	Average, 1881-90,	.07
Average, twenty years,			.64

By this it appears that the mortality rate of the first ten years was nearly twenty times as great as that of the second. The deaths from this cause for 1871–80 were 2,153, and those of the second decade were only 137. The annual mortality rate for the whole period was .64 per 10,000. The ratio of deaths from small-pox to the mortality from all causes was three-tenths of one per cent.

Distribution by Counties.

The deaths from small-pox were distributed by counties as follows for the twenty years (1871–90), the ratio of mortality in each being also stated: —

COUNTIES.	Deaths.	Ratio per 10,000 of the Population.
Barnstable,	15	.23
Berkshire,	43	.31
Bristol,	56	.20
Dukes,	1	.12
Essex,	118	.24
Franklin,	4	.05
Hampden,	257	1.23
Hampshire,	29	.30
Middlesex,	445	.70
Nantucket,	0	.00
Norfolk,	45	.23
Plymouth,	12	.08
Suffolk,	1,149	1.48
Worcester,	124	.27
THE STATE,	2,298	.64

By the foregoing table it appears that the distribution of small-pox was by no means uniform. The extremes were ratios of 0 and .1 in the island counties of Nantucket and Dukes, and 1.23 and 1.48 per 10,000 in Hampden and Suffolk.

In the following table the counties are arranged in accordance with their mortality rate from small-pox, the State being taken as 100 : —

Counties arranged according to their Death Rates from Small-pox (1871–90), that of the State being taken as 100, and the Density of Population being expressed in Acres per Inhabitant.

COUNTIES.	Density of Population, Acres per Inhabitant. 1880.	Mortality Rate from Small-pox, the State = 100.
Nantucket,	11.2	0
Franklin,	11.8	8
Plymouth,	5.9	12
Dukes,	18.4	19
Bristol,	2.5	31
Norfolk,	3.3	36
Barnstable,	7.5	36
Essex,	1.3	37
Worcester,	4.4	42
Hampshire,	7.7	47
Berkshire,	8.9	48
THE STATE,	**2.9**	**100**
Middlesex,	1.7	109
Hampden,	3.9	192
Suffolk,	.07	231

In the following table the counties are again arranged in accordance with their density of population in three groups, the mortality rank also being expressed, as before : —

Counties grouped according to their Density of Population.	COUNTIES.	Acres to Each Person.		Mortality Rank from Small-pox.	
I. County in which there is less than one acre to each person,	Suffolk,	0.7		241	
II. Counties having more than one acre but less than four acres to each person,	Essex,	1.3	Average, 2.1.	37	Average, 80.
	Middlesex,	1.7		109	
	Bristol,	2.5		31	
	Norfolk,	3.3		36	
	Hampden,	3.9		192	
III. Counties having more than four acres to each inhabitant,	Worcester,	4.4	Average, 6.4.	42	Average, 36.
	Plymouth,	5.9		12	
	Hampshire,	7.7		47	
	Berkshire,	8.9		48	
	Barnstable, Dukes and Nantucket,	9.0		31	
	Franklin,	11.8		8	

By the foregoing table it appears that the incidence of fatality from small-pox fell most heavily upon the district with the densest population and least heavily upon the most sparsely settled counties, while the medium districts ranged between, the extremes being greater than in the case of either of the other diseases considered in this paper.

Other conditions which appear to have influenced the ratio of small-pox mortality will be referred to under the classification by towns.

Stating the mortality of the dense districts as 1,000, that of these three groups was as follows: —

Mortality of *dense* districts from small-pox, ...	1,000
Mortality of *medium* districts from small-pox, . . .	332
Mortality of *sparse* districts from small-pox, ...	149

Classification by Towns.

It is to be noted at the outset that deaths from small-pox occurred in only 161 out of the 346 cities and towns of Massachusetts during the period of twenty years, leaving 185 towns in which there were no deaths from this cause. (See Map No. 4.) Furthermore, there were 63 towns in which only one death occurred from this cause in each, and 29 other towns in which only two such deaths occurred.

Deaths from small-pox occurred in each of the 28 cities during this period, the numbers of deaths from small-pox and the numerical rank being as follows: —

	Deaths.	Numerical Rank, the State = 100.		Deaths.	Numerical Rank, the State = 100.
Brockton, . . .	2	9	Marlborough, . .	6	45
Newton, . . .	3	12	Salem, ...	16	45
New Bedford, . .	6	16	Fall River, . . .	31	48
Northampton, . .	3	19	Worcester, . . .	37	48
Haverhill, . . .	5	20	Lawrence, . . .	24	51
Woburn, . . .	3	22	Malden, . . .	9	51
Taunton, . . .	6	22	Quincy, . . .	10	70
Newburyport, . .	4	23	Gloucester, . . .	18	72
Fitchburg, . . .	6	31	Springfield, . . .	33	75
Lynn, ...	17	33	Chelsea, . . .	27	92
Chicopee, . . .	5	34	Cambridge, . . .	67	97
Pittsfield, . . .	6	34	Lowell, . . .	184	248
Somerville, . . .	13	39	Boston, . . .	1,203	261
Waltham, . . .	7	42	Holyoke, . . .	178	619

The 185 towns which had no deaths from small-pox may be considered as one extreme, and the 11 towns which had the highest ratios as the other extreme. The characteristics of these 185 towns may be stated mainly as a sparse population, and remoteness from densely crowded cities and towns. Not one of the whole number had 6,000 inhabitants by the census of 1880, and only 6 had more than 4,000 inhabitants in each.

There were 17 contiguous towns in south-western Massachusetts in which no deaths occurred from this cause. In another district, comprising the whole of Franklin County and 6 towns of north-eastern Berkshire, there were but 4 small-pox deaths.

In the whole of Plymouth County there were but 12 deaths from this cause, and these were distributed in 8 towns. In the whole of Barnstable County there were only 14 deaths from small-pox, and these were distributed in 7 towns, an average of two in each.

In the 7 island towns of Dukes and Nantucket counties there was but one death from small-pox.

At the other extreme stand 11 cities and towns with high ratios. In these there were 1,616 deaths from small-pox during the period in question, and of this number 1,565, or nearly 97 per cent., occurred in the three cities of Boston, Lowell and Holyoke.

The Relation of Paper Mills to Small-pox Mortality.

The manufacture of paper is one of the principal industries of Massachusetts. About one-third of the rags imported into the United States is used in Massachusetts paper mills. The majority of the mills are in towns and cities situated upon the Connecticut, Westfield and Housatonic rivers. The following list includes the cities and towns in which there were paper mills, all of which used rags, either domestic, foreign, or both, in paper manufacture: —

Adams.	Great Barrington.	Leominster.	Russell.
Becket.	Groton.	Middleton.	South Hadley.
BOSTON.	Hardwick.	Milton.	Ware.
Cummington.	HOLYOKE.	Montague.	Westfield.
Dalton.	Huntington.	Needham.	Westhampton.
Erving.	LAWRENCE.	Newton.	West Springfield.
FITCHBURG.	Lee.	Pepperell.	Wilbraham.

NOTE. — By an error the towns of Needham and Ware were marked upon the map for small-pox as having no deaths from this cause. There were 3 deaths in Needham and 7 in Ware from small-pox.

In the list of 11 cities and towns having extremely high ratios, 6 contained one or more paper mills in which rags were used. The origin of the cases in Montgomery was traced directly to an adjoining paper-mill town. Furthermore, the foregoing list of 28 paper-mill cities and towns contains only 5 places in which there were no small-pox deaths during the period of twenty years, and non-fatal cases were known to have occurred in two of these towns.

Again, out of the 68 paper mills in Massachusetts, in which rags either domestic or foreign were used for paper manufacture, only 5 were located in the 185 towns in which there were no deaths from small-pox during the twenty years.

Frequent investigations of the State Board of Health have shown that small-pox in Massachusetts is very often due to infected rags. Out of the first 12 cases of small-pox which occurred at Holyoke in 1880, 11 were females employed in cutting and sorting rags, and the twelfth was a child in the family of a rag-cutter. Investigation in many of these cases showed that the probability as to the source of infection was largely in favor of domestic rags collected in the large cities of the United States. Further information upon this point is contained in Dr. Withington's article upon "The transmission of infectious diseases through the medium of rags," in the eighteenth report of the State Board of Health (1886).

Railway Communication. — Of the 161 towns in which deaths occurred from small-pox, only 8, Williamsburg, Warwick, Leicester, Cummington, Holland, Chatham, Burlington and Tisbury were not directly upon some line of railway communication at the time when the deaths occurred. There were 13 deaths in these 8 towns.

In the following places, upon the Boston & Albany Railroad and its branches, deaths from small-pox occurred at some time in the period of twenty years, starting with the metropolitan centre, Boston: Brookline, Newton, Natick, Framingham, Ashland, Hopkinton, Westborough, Grafton, Millbury, Worcester, Auburn, Charlton, Spencer, Brookfield, North Brookfield, Palmer, Wilbraham, Ludlow, Springfield, West Springfield, Agawam, Westfield, Montgomery, Russell, Huntington, Chester, Becket, Dalton, Pittsfield, Lanesborough, Cheshire and Adams.

Upon the Old Colony Railroad and its branches: Dedham, Hyde Park, Milton, Quincy, Hingham, Weymouth, Braintree, Canton, Walpole, Foxborough, Attleborough, Easton, Brockton, Marshfield, Plympton, Plymouth, Wareham, Lakeville, Mattapoisett, Taunton, Dighton, Fall River, Westport, Dartmouth, New Bedford, Falmouth, Sandwich, Barnstable, Harwich, Truro, Provincetown, Marlborough, Bolton, Clinton and Leominster.

On the Fitchburg Railroad: Somerville, Cambridge, Watertown, Waltham, Concord, Acton, Maynard, Ayer, Fitchburg, Ashburnham, Winchendon, Gardner, Athol, Montague, Deerfield, North Adams and Williamstown.

On the Boston & Maine: Arlington, Lexington, Medford, Malden, Melrose, Everett, Chelsea, Revere, Saugus, Lynn, Salem, Winchester, Woburn, Arlington, Reading, North Reading, Stoneham, Wakefield, Marblehead, Beverly, Manchester, Gloucester, Peabody, Danvers, Topsfield, Newbury, Newburyport, Amesbury, Groveland, Haverhill, Andover, North Andover, Lawrence, Lowell, Chelmsford, Westford, Groton, Pepperell, Lancaster, West Boylston, Holden, Barre, Enfield, Granby, South Hadley and Northampton.

Nearly every town within a radius of fifteen miles from Boston had one or more deaths from this cause, the greatest numbers being in Cambridge (67) and in Chelsea (27).

Towns contiguous to and in close communication by railway with other large cities also suffered, to a greater or less extent, as in the case of Westport and Dartmouth, next to Fall River and New Bedford; of 6 towns lying contiguous to Worcester; of as many more towns contiguous to Springfield, Chicopee and Holyoke; of Chelmsford, Westford and Ayer, lying in direct communication between Lowell and the paper-mill towns of Pepperell and Groton; of North Andover and Andover, joining Lawrence and in direct communication with it.

In Boston the density of population (10,000 to the square mile) undoubtedly far outweighs any effect which may be attributed to one or more small paper mills which were located within the city limits upon the Neponset River during the period in question.

In the following towns there were no deaths from small-pox during the twenty years (1871–90): —

Abington.
Acushnet.
Alford.
Amherst.
Ashby.
Ashfield.
Bedford.
Belchertown.
Bellingham.
Belmont.
Berkley.
Berlin.
Bernardston.
Billerica.
Blandford.
Boxborough.
Boxford.
Boylston.
Bradford.
Brewster.
Bridgewater.
Brimfield.
Buckland.
Carlisle.
Carver.
Charlemont.
Chesterfield.
Chilmark.
Clarksburg.
Cohasset.
Colrain.
Conway.
Cottage City.
Dana.
Dennis.
Dover.
Dracut.
Dunstable.
Duxbury.
East Bridgewater.
Eastham.
Edgartown.
Egremont.
Erving.
Essex.
Fairhaven.
Florida.
Freetown.
Gay Head.
Georgetown.
Gill.
Goshen.
Gosnold.
Granville.
Great Barrington.
Greenfield.
Greenwich.
Hadley.
Halifax.
Hamilton.
Hampden.
Hancock.
Hanover.
Hanson.
Hardwick.
Harvard.
Hawley.
Heath.
Hinsdale.
Holbrook.
Hubbardston.
Hudson.
Hull.
Ipswich.
Kingston.
Leverett.
Leyden.
Lincoln.
Littleton.
Lunenburg.
Lynnfield.
Mansfield.
Marion.
Mashpee.
Medfield.
Mendon.
Merrimac.
Methuen.
Middleborough.
Middlefield.
Middleton.
Monroe.
Monson.
Monterey.
Mount Washington.
Nahant.
Nantucket.
New Ashford.
New Braintree.
New Marlborough.
New Salem.
Northborough.
Northfield.
Norfolk.
Norton.
Norwell.
Norwood.
Oakham.
Orange.
Orleans.
Otis.
Oxford.
Paxton.
Pembroke.
Peru.
Petersham.
Phillipston.
Plainfield.
Prescott.
Randolph.
Raynham.
Rehoboth.
Richmond.
Rochester.
Rockland.
Rockport.
Rowe.
Rowley.
Royalston.
Rutland.
Sandisfield.
Savoy.
Scituate.
Seekonk.
Sharon.
Sheffield.
Shelburne.
Sherborn.
Shirley.
Shrewsbury.
Shutesbury.
Somerset.
Southampton.
Southborough.
Southwick.
Sterling.
Stockbridge.
Stoughton.
Stow.
Sudbury.
Sunderland.
Sutton.
Swampscott.
Swanzey.
Templeton.
Tewksbury.
Tolland.
Townsend.
Tyngsborough.
Tyringham.
Upton.
Wales.
Warren.
Washington.
Wayland.
Wellesley.
Wellfleet.
Wendell.
Wenham.
West Bridgewater.
West Brookfield.
Westhampton.
Westminster.
West Newbury.
Weston.
West Stockbridge.
Whately.
Whitman.
Windsor.
Winthrop.
Worthington.
Wrentham.
Yarmouth.

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Small-pox (1871-90), the Rate for Massachusetts being taken as 100.

Cities and towns in which the mortality from small-pox was more than fifty per cent. below the average of the State: —

	Number of Deaths from Small-pox.	Mortality Rank, the State =100.		Number of Deaths from Small-pox.	Mortality Rank, the State =100.
Beverly, ...	1	9	Newton, ...	3	12
Brookline, ...	1	9	Leominster, ...	1	14
BROCKTON, ...	2	9	Wakefield, ...	1	14
Dedham, ...	1	12	Watertown, ...	1	14

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Small-pox, etc. — Continued.

	Number of Deaths from Small-pox.	Mortality Rank, the State = 100.		Number of Deaths from Small-pox.	Mortality Rank, the State = 100.
Attleborough,	2	14	Ashland,	1	33
NEW BEDFORD,	6	16	Barre,	1	33
Andover,	1	16	LYNN,	17	33
Hopkinton,	1	17	CHICOPEE,	5	34
Hingham,	1	17	Montague,	2	34
Canton,	1	17	Maynard,	1	34
Franklin,	1	19	Williamsburg,	1	34
Arlington,	1	19	Douglas,	1	34
Grafton,	1	19	Athol,	2	34
NORTHAMPTON,	3	19	PITTSFIELD,	6	34
North Adams,	2	19	Westford,	1	36
Easton,	1	20	Peabody,	4	36
HAVERHILL,	5	20	Lenox,	1	36
Williamstown,	1	20	Sturbridge,	1	37
Sandwich,	1	22	Braintree,	2	37
Deerfield,	1	22	Concord,	2	39
WOBURN,	3	22	Lancaster,	1	39
TAUNTON,	6	22	SOMERVILLE,	13	39
Milton,	1	23	Medford,	4	39
Southbridge,	2	23	Ayer,	1	41
NEWBURYPORT,	4	23	Charlton,	1	41
Harwich,	1	23	WALTHAM,	7	42
Danvers,	2	23	Winchendon,	2	42
Uxbridge,	1	25	Acton,	1	44
North Andover,	1	25	Plymouth,	4	44
Webster,	2	26	MARLBOROUGH,	6	45
Wareham,	1	26	SALEM,	16	45
Westport,	1	26	Amesbury,	3	45
Dudley,	1	28	Marshfield,	1	47
Palmer,	2	28	Weymouth,	6	47
Brookfield,	1	28	Manchester,	1	47
Natick,	3	28	FALL RIVER,	31	48
Gardner,	2	28	WORCESTER,	37	48
Westborough,	2	30	Reading,	2	48
Everett,	2	30	Longmeadow,	1	48
Clinton,	3	30	Cheshire,	1	50
Chelmsford,	1	31	Holliston,	2	50
FITCHBURG,	6	31	Newbury,	1	50

Cities and towns in which the mortality from small-pox was below the average but not fifty per cent. below it: —

LAWRENCE,	24	51	Barnstable,	3	55
MALDEN,	9	51	Revere,	3	55
Ludlow,	1	52	Hyde Park,	5	55
Tisbury,	1	52	Mattapoisett,	1	56
Hatfield,	1	52	Leicester,	2	56
Chester,	1	53	Salisbury,	3	56

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Small-pox, etc. — Concluded.

	Number of Deaths from Small-pox.	Mortality Rank, the State =100.		Number of Deaths from Small-pox.	Mortality Rank, the State =100.
Saugus,	2	56	Ashburnham,	2	77
Framingham,	5	58	Lakeville,	1	78
Lanesborough,	1	59	Foxborough,	3	80
Auburn,	1	59	Lee,	4	80
Needham,	3	61	Stoneham,	5	80
Winchester,	3	61	Spencer,	8	83
Huntington,	1	63	Groton,	2	84
Holden,	2	63	Wilmington,	1	84
Walpole,	2	63	Westfield,	9	84
Falmouth,	2	64	Bolton,	1	86
Milford,	8	66	North Reading,	1	87
Chatham,	2	69	Provincetown,	5	89
QUINCY,	10	70	Dartmouth,	4	91
Princeton,	1	70	Easthampton,	5	92
GLOUCESTER,	18	72	CHELSEA,	27	92
Melrose,	5	73	West Springfield,	5	94
Enfield,	1	75	CAMBRIDGE,	67	97
SPRINGFIELD,	33	75	THE STATE,	2,298	100
Truro,	1	76			

Towns in which the mortality from small-pox was greater than that of the State but not fifty per cent. greater: —

Ware,	7	103	Plympton,	1	112
Granby,	1	103	Dalton,	3	114
Marblehead,	10	103	Millbury,	7	116
Groveland,	3	105	Pelham,	1	126
North Brookfield,	6	105	Pepperell,	4	133
West Boylston,	4	105	Topsfield,	2	134
Warwick,	1	109	Northbridge,	7	134
Burlington,	1	109	Medway,	7	137
Blackstone,	7	111	Becket,	2	139
South Hadley,	5	111	Lexington,	5	149

Cities and towns in which the mortality from small-pox was more than fifty per cent. above that of the State: —

Adams,	21	162	BOSTON,	1,203	261
Wilbraham,	4	191	Cummington,	3	266
Dighton,	5	217	Montgomery,	2	516
Agawam,	7	247	HOLYOKE,	178	619
LOWELL,	184	248	Russell,	7	664
Holland,	1	258			

TYPHOID FEVER.

The number of deaths registered as from typhoid fever in Massachusetts during the twenty years (1871–90) was 19,421. The annual mortality from this cause was 5.4 per 10,000 of the

population. It was also 2.7 per cent. of the mortality from all causes for the twenty years (1871–90). The mortality rate from this cause for each year of the period was as follows: —

YEARS.	Mortality Rate from Typhoid Fever per 10,000 of the Population.	YEARS.	Mortality Rate from Typhoid Fever per 10,000 of the Population.
1871,	7.5	1881,	5.9
1872,	11.1	1882,	5.6
1873,	8.9	1883,	4.5
1874,	7.1	1884,	4.5
1875,	6.4	1885,	3.9
1876,	5.3	1886,	4.1
1877,	4.9	1887,	4.5
1878,	4.1	1888,	4.6
1879,	3.7	1889,	4.1
1880,	4.9	1890,	3.7
Average, ten years, 1871-80,	6.2	Average, ten years, 1881-90,	4.5
Average of twenty years,			5.4

The average mortality rate of the last half of the twenty-year period was less than that of the first half.

Distribution by Counties.

The ratios of mortality from typhoid fever by counties for the period (1871–90) were as follows: —

COUNTIES.	Number of Deaths from Typhoid Fever.	Ratio per 10,000 of the Population.
Barnstable,	351	5.5
Berkshire,	1,053	7.6
Bristol,	1,660	6.0
Dukes,	50	5.8
Essex,	2,541	5.2
Franklin,	438	6.1
Hampden,	1,772	8.5
Hampshire,	644	6.8
Middlesex,	3,101	4.9—
Nantucket,	35	4.7
Norfolk,	797	4.1
Plymouth,	717	4.8
Suffolk,	3,825	4.9+
Worcester,	2,437	5.4
THE STATE,	19,421	5.4

An examination of the foregoing table shows that the extremes are Norfolk, with the low ratio of 4.1, and Hampden, with the high mortality of 8.5 per 10,000 of the population.

Other counties having low ratios were Middlesex, Nantucket, Plymouth and Suffolk, and those having highest ratios (beside Hampden) were Berkshire and Hampshire. That portion of each of the three Connecticut valley counties lying east of the river suffered more than the western portion of these counties.

The eastern part of Middlesex County and all of the suburban towns contiguous to Boston had a low mortality rate from typhoid fever. The sea-coast counties generally had low ratios.

In the following table the counties are arranged with reference to their death rates from typhoid fever. The counties having the lowest ratio appear at the top of the list, and the mortality of the State from the same cause is taken as a basis of comparison: —

Counties of Massachusetts arranged according to their Death Rates from Typhoid Fever (1871–90), that of the State being taken as 100, and the Density of Population expressed in Acres to Each Person.

COUNTIES.	Density of Population. Acres to Each Person.	Mortality Rank.
Norfolk,	3.3	76
Nantucket,	11.2	86
Plymouth,	5.9	89
Middlesex,	1.7	90
Suffolk,	.07	91
Essex,	1.3	95
Worcester,	4.4	99
THE STATE,	2.9	100
Barnstable,	7.5	101
Dukes,	18.4	107
Bristol,	2.5	110
Franklin,	11.8	112
Hampshire,	7.7	125
Berkshire,	8.9	140
Hampden,	3.9	156

In the following table the counties are arranged in three groups, according to their density of population, the county

having the greatest density being placed at the top of the list: —

COUNTIES GROUPED ACCORDING TO THEIR DENSITY OF POPULATION.	COUNTIES.	Acres to Each Person.		Mortality Rank from Typhoid Fever, the State = 100.	
I. County in which there is less than one acre to each inhabitant, ...	Suffolk, . . .	.07		91	
II. Counties having more than one but less than four acres to each inhabitant, . .	Essex, . . .	1.8	Average, 2.1.	95	Average, 101.
	Middlesex, . .	1.7		90	
	Bristol, . . .	2.5		110	
	Norfolk, . . .	3.3		76	
	Hampden, . .	3.9		156	
III. Counties having more than four acres to each inhabitant, ...	Worcester, . .	4.4	Average, 6.4.	99	Average, 107.
	Plymouth, . .	5.9		89	
	Hampshire, . .	7.7		125	
	Berkshire, . .	8.9		140	
	Barnstable, Dukes and Nantucket, .	9.0		100	
	Franklin, . . .	11.8		112	

The foregoing table shows that the mortality from typhoid fever does not depend upon the density of population as the principal favoring condition for its spread. The most densely settled metropolitan district had a comparatively low mortality rate from this cause, while the group of sparsely settled counties had an average high ratio of mortality from typhoid fever.

Hampden County stands prominent for its very high ratio in the intermediate group, while Norfolk, in the same group, had the lowest ratio.

Estimating the mortality of the densely settled districts as 1,000, the mortality of these three groups from typhoid fever was as follows: —

The *dense* districts, ...	1,000
The *medium* districts, ...	1,109
The *sparse* districts, ...	1,175

Classification by Towns.

Generally speaking, the towns of the western half of the State had a higher mortality from typhoid fever than those of the eastern half. (See Map No. 5.)

An examination of the extremes reveals no very striking characteristics. But one town, Gosnold (the smallest in population), had no deaths from typhoid fever during the twenty years. This town comprises the Elizabeth Islands, lying at the mouth of Buzzard's Bay. Its population in 1880 was 152.

The 20 towns having the lowest rank in the list are scattered throughout the State in ten of the counties, and, with the exception of one of the smaller cities (Waltham), are small towns. Twelve of this number had less than 1,000 inhabitants in each in 1880. There does not appear to be any point of special significance relative to these 20 towns.

Of the 20 towns which hold the highest position upon the list, 17 are in the four western counties and the western border of Worcester County. Dalton, with the highest ratio, is a manufacturing town (paper mills) among the Berkshire hills, lying at an elevation of more 1,000 feet above the sea level. Ware, Brookfield, Great Barrington and Westfield are also manufacturing towns of western Massachusetts. Ten of the remaining towns are small agricultural towns, having a population in each of less than 1,000, and their position may hence be regarded as having but little significance.

The city of Holyoke, which had 498 deaths from typhoid fever in the twenty-year period, and ranked 203 in this list as compared with the State (100), is a manufacturing city of rapid growth. Its population in 1870 was 10,733; in 1880, 21,915; and in 1890, 35,637. The principal industry is the manufacture of paper.

Dividing the towns into a more accurate classification, without regard to county lines, the towns which may be considered as having a dense population (87 in number) had a mortality rate of 5.15 per 10,000 annually from typhoid fever, while the remaining towns (259 in number) had a mortality rate of 5.54 per 10,000.

The mortality from typhoid fever in towns during the period under consideration may be compared with a previous period of ten years, for which the data were compiled by Dr. Geo. Derby, for the second annual report of the State Board of Health (1871). The period which he selected was the ten years 1859–68. During this period the 10 towns which had

the lowest mortality rate from typhoid fever were as follows, beginning with the town having the lowest mortality rate from this cause: —

Revere.	Seekonk.
Belmont.	Dover.
Winchester.	Brookline.
Boxborough.	Hingham
Lanesborough.	Dunstable.

All of these towns also had low mortality ratios from typhoid fever in the second period (1871–90), except Dover and Seekonk.

The 10 towns which had the highest mortality from this cause (1859–68) were as follows, ending with the town having the highest ratio: —

Leverett.	Blandford.
Richmond.	Otis.
Granville.	Savoy.
Phillipston.	Royalston.
Southampton.	Sheffield.

All of these towns except Richmond had high ratios in the later period (1871–90).

It is worthy of note that most of the foregoing 10 towns having low mortality rates in 1859–68 are comparatively near the sea-coast and at low elevations above sea level, while all of the 10 towns having the highest ratios are inland towns, and mostly west of the Connecticut River, with an average elevation of eight hundred feet above the sea.

The cities which had specially high death rates from typhoid fever in the later period (1871–90) — Holyoke, Lowell, Lawrence, Fall River and Chicopee — held an intermediate position in 1859–68; and it was not until after a polluted water supply had been introduced in Lowell and Lawrence that their death rates from typhoid fever reached an unusually high figure.

The well-known relation of typhoid fever to the pollution of domestic water supplies suggests a statistical consideration of this subject. The writer acknowledges the difficulty which attends a purely statistical presentation, in the absence of facts which are essential to an intelligent view of the subject.

The facts which are wanting are the comparative numbers of persons using the water of pure supplies, and those who use

water from polluted sources; since there are very many towns in which a large part of the population in the more densely settled portion uses the water of some well-known but pure supply, while among the sparsely settled districts of such towns are many private wells which furnish polluted water. On the other hand, there may exist, as in some of the large cities located on rivers, a polluted public supply which is of a more dangerous character than the average household well. Unfortunately for statistical purposes there is no distinct census grouping of these classes of the population.

In general the following facts are known. During the period in question (1871-90) the number of public water supplies in Massachusetts had increased from twenty in 1871 to one hundred and thirty-two in 1890. The population of towns supplied in 1871 was about one-third of the whole population of the State, while that of the towns supplied in 1890 comprised nearly five-sixths of the total population of the State.

Comparing the foregoing with the mortality from typhoid fever, the ratio of mortality from typhoid fever per 10,000 of the population in 1871 was 7.5, and in 1890 it was 3.7. But, since the statistics of a single year are less conclusive than those of a group of years, we find that the average mortality of the State for the first five years (1871–75) was 8.2 per 10,000, or nearly double that of the last five-year period (1886–90), which was only 4.2 per 10,000.

On examination of the complete list of towns presented on pages 826–830, the statistics are less conclusive, in consequence of the insufficiency of the data, as already stated.

Out of the 195 cities and towns having ratios of mortality from typhoid fever less than the average of the State for the twenty years, 89, or 46 per cent., had public water supplies which were introduced either at some time during this period or at a previous date. This group of cities and towns had a population of 1,250,905, or 70 per cent. of the population of the State, by census of 1880.

Of the 148 cities and towns which had ratios of mortality from typhoid fever greater than the average of the State, only 43, or 29 per cent., had water supplies. This group had a population of 532,180, or 30 per cent. of the population of the State.

having the greatest density being placed at the top of the list: —

Counties grouped according to their Density of Population.	COUNTIES.	Acres to Each Person.		Mortality Rank from Typhoid Fever, the State = 100.	
I. County in which there is less than one acre to each inhabitant, ...	Suffolk, . . .	.07		91	
II. Counties having more than one but less than four acres to each inhabitant, . .	Essex, . . .	1.3	Average, 2.1.	95	Average, 101.
	Middlesex, . .	1.7		90	
	Bristol, . . .	2.5		110	
	Norfolk, . . .	3.3		76	
	Hampden, . .	3.9		156	
III. Counties having more than four acres to each inhabitant, ...	Worcester, . .	4.4	Average, 6.4.	99	Average, 107.
	Plymouth, . .	5.9		89	
	Hampshire, . .	7.7		125	
	Berkshire, . .	8.9		140	
	Barnstable, Dukes and Nantucket, .	9.0		100	
	Franklin, . . .	11.8		112	

The foregoing table shows that the mortality from typhoid fever does not depend upon the density of population as the principal favoring condition for its spread. The most densely settled metropolitan district had a comparatively low mortality rate from this cause, while the group of sparsely settled counties had an average high ratio of mortality from typhoid fever.

Hampden County stands prominent for its very high ratio in the intermediate group, while Norfolk, in the same group, had the lowest ratio.

Estimating the mortality of the densely settled districts as 1,000, the mortality of these three groups from typhoid fever was as follows: —

The *dense* districts, ...	1,000
The *medium* districts, ...	1,109
The *sparse* districts, ...	1,175

Classification by Towns.

Generally speaking, the towns of the western half of the State had a higher mortality from typhoid fever than those of the eastern half. (See Map No. 5.)

Typhoid Fever — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Rowley,	9	69	Upton,	19	86
Brimfield,	9	69	Boxborough,	3	86
Freetown,	10	69	Chelmsford,	24	86
GLOUCESTER,	148	69	Ipswich,	35	87
Orange,	24	69	NORTHAMPTON,	116	87
Williamsburg,	17	70	Tyngsborough,	6	87
Hyde Park,	55	70	NEW BEDFORD,	282	87
Ashby,	7	70	Carlisle,	5	88
Peabody,	69	72	Salisbury,	39	88
Winchendon,	29	72	MARLBOROUGH,	99	88
Middleborough,	41	72	Newbury,	15	88
Yarmouth,	17	72	Holliston,	30	89
Falmouth,	19	72	Ashburnham,	20	89
Wenham,	7	72	New Ashford,	2	90
Templeton,	22	72	Shelburne,	16	91
MALDEN,	110	73	TAUNTON,	216	91
Stoneham,	39	73	Northbridge,	40	91
Canton,	36	73	Sandwich,	35	91
Framingham,	54	73	Norwell,	18	91
Stoughton,	39	73	Deerfield,	35	91
Mattapoisett,	11	74	Groveland,	22	91
Winchester,	31	75	Petersham,	11	91
Blackstone,	41	77	Athol,	46	92
Mansfield,	24	78	SALEM,	273	92
Cheshire,	13	78	Shrewsbury,	15	92
CHELSEA,	194	78	Dracut,	16	92
Natick,	72	78	Acton,	18	92
Danvers,	56	78	Hatfield,	15	92
Hamilton,	8	78	Sharon,	15	92
Lanesborough,	11	79	Scituate,	25	93
Saugus,	24	79	Sudbury,	12	94
Groton,	16	79	Randolph,	41	94
Wareham,	25	79	Medfield,	14	94
WORCESTER,	522	79	BOSTON,	3,667	94
Eastham,	7	80	Edgartown,	14	94
Lynnfield,	6	80	Ashfield,	11	95
Shirley,	12	81	Swanzey,	14	95
Chester,	13	81	HAVERHILL,	197	95
Dedham,	55	81	Rutland,	11	95
LYNN,	355	81	Greenfield,	44	96
Pepperell,	21	82	Merrimac,	17	96
BROCKTON,	144	82	Huntington,	13	97
Easton,	35	82	Lenox,	23	97
Cummington,	8	83	Barnstable,	45	97
Florida,	7	84	Medway,	42	98
New Salem,	8	85	Bellingham,	13	98
Swampscott,	23	85	Chatham,	24	98
QUINCY,	104	85	Spencer,	80	98
Windsor,	6	85	Southwick,	12	100
Granby,	7	85			
Nantucket,	35	86	THE STATE,	19,421	100

Typhoid Fever — Continued.

Cities and towns in which the mortality from typhoid fever was above the average but not fifty per cent. above it: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Lunenburg,	12	100	Milford,	118	116
West Stockbridge,	21	100	Bernardston,	12	118
Mendon,	12	101	Halifax,	7	118
Tolland,	5	102	Auburn,	17	118
Greenwich,	7	102	Marshfield,	23	119
Winthrop,	14	102	Williamstown,	48	119
Attleborough,	124	102	Leicester,	36	119
Easthampton,	47	103	Chesterfield,	10	119
Methuen,	50	105	Orleans,	17	121
Seekonk,	14	105	Granville,	16	122
Sherborn,	16	105	Cottage City,	6	122
Hanson,	15	105	Southampton,	14	123
Oakham,	10	106	Royalston,	16	123
Braintree,	48	106	Harwich,	44	124
Norton,	20	106	Pembroke,	19	124
Bradford,	32	106	Stockbridge,	32	125
Manchester,	19	106	Sheffield,	30	125
Hanover,	22	107	Ashland,	33	127
Sturbridge,	24	107	Douglas,	31	127
Wales,	12	107	West Springfield,	58	128
Townsend,	23	107	Norfolk,	13	129
Boylston,	10	107	FALL RIVER,	711	129
Millbury,	56	108	Grafton,	57	130
Colrain,	21	109	Monson,	53	130
Princeton,	13	109	Palmer,	78	130
Paxton,	7	109	Conway,	25	130
Warren,	46	109	Berlin,	14	132
Raynham,	20	109	Alford,	5	132
Sunderland,	9	109	Wrentham,	36	133
Hinsdale,	19	109	Phillipston,	9	133
Harvard,	15	110	SPRINGFIELD,	503	134
Holden,	30	110	North Adams,	123	134
Sterling,	17	110	Hopkinton,	68	136
Topsfield,	14	110	Barre,	36	137
Westminster,	20	111	Longmeadow,	24	137
Bridgewater,	44	112	North Andover,	48	137
Washington,	6	112	Dana,	11	137
Dover,	8	112	Dudley,	42	138
PITTSFIELD,	168	113	Gill,	11	138
Abington,	46	114	Duxbury,	33	138
Rochester,	13	114	Littleton,	15	139
Westborough,	65	114	Clarksburg,	11	140
Northborough,	21	115	Prescott,	7	140
Rockport,	49	115	Amherst,	66	141
Warwick,	9	116	Savoy,	11	141
Amesbury,	65	116	Carver,	16	141
Buckland,	22	116	Sutton,	48	142

Typhoid Fever — Concluded.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
North Brookfield, . .	69	142	Erving, ...	14	147
Westport, . . .	45	143	Charlemont, . . .	15	148
Montague, . . .	70	144	Hardwick, . . .	36	148
West Boylston, . .	47	144	Blandford, . . .	16	150
Russell, ...	13	145	Ludlow, ...	25	150
Hudson, ...	60	147			

Cities and towns in which the mortality from typhoid fever was more than fifty per cent. above the average of the State: —

New Marlborough, . .	31	152	Northfield, . . .	30	172
Bolton, ...	15	153	Becket, ...	21	172
Brewster, ...	19	153	Marion, ...	18	173
Belchertown, . . .	39	153	Leverett, ...	14	173
CHICOPEE, . . .	189	154	Westfield, . . .	156	173
Hawley, ...	10	155	Otis, ...	15	175
LOWELL, ...	977	155	Egremont, . . .	17	178
Adams, ...	170	155	Great Barrington, . .	91	180
South Hadley, . . .	60	156	Monroe, ...	4	181
Hadley, ...	33	156	New Braintree, . .	12	181
Worthington, . . .	13	158	Agawam, . . .	45	186
Wendell, ...	8	158	Wilbraham, . . .	34	192
Lee, ...	69	161	Dennis, ...	69	193
Webster, ...	100	161	Brookfield, . . .	62	202
Southbridge, . . .	114	162	HOLYOKE, . . .	498	203
Westhampton, . .	10	163	Shutesbury, . . .	12	208
Hubbardston, . . .	25	166	Pelham, ...	14	209
Sandisfield, . . .	20	166	Mashpee, . . .	8	212
Tyringham, . . .	10	169	Middlefield, . . .	15	213
Tisbury, ...	28	169	Ware, ...	128	221
LAWRENCE, . . .	689	170	Dalton, ...	51	228

CHOLERA INFANTUM.

This disease, which is responsible for a large share of the mortality of children in New England during the summer months, caused the death of 42,375 children during the period of twenty years (1871–90). The death rate from this cause was 11.9 per 10,000 for the twenty-year period, and the ratio to the total mortality was 5.9 per cent. Undoubtedly many cases of death are recorded under this head which properly belong under the title of other diarrhœal diseases of children. It is, however, not always an easy matter to draw a sharp line of distinction. Hence the statistics must be taken as they are.

The annual mortality attributed to this cause for each year during the period was as follows: —

YEARS.	Death Rate per 10,000 from Cholera Infantum.	YEARS.	Death Rate per 10,000 from Cholera Infantum.
1871,	11.5	1881,	10.2
1872,	21.2	1882,	11.7
1873,	16.2	1883,	10.3
1874,	14.4	1884,	10.9
1875,	15.8	1885,	9.5
1876,	12.6	1886,	9.8
1877,	11.6	1887,	10.6
1878,	9.4	1888,	10.7
1879,	7.9	1889,	9.9
1880,	11.3	1890,	11.1
Average, ten years, 1871-80,	13.0	Average, ten years, 1881-90,	10.4
Average of twenty years,			11.88

The mortality rate from cholera infantum for the second period of ten years was less than that of the first ten years.

This table shows a great difference in the mortality of different years of the period under consideration, the extremes being 21.2 per 10,000 in 1872 and 7.9 in 1879. The year 1872 was a year of unusually high mortality for most of the infectious diseases, and the general death rate (22.8 per 1,000) was the highest not only during the twenty-year period but also during the forty years (1851–90). The mortality rate from small-pox, measles, scarlet-fever, typhoid fever and also from phthisis was in each case higher in 1872 than the average of the twenty years.

In connection with these data it should be added that the birth rate of 1872 was also comparatively high, although it was slightly exceeded in 1873 and in 1874; while the birth rate of 1879 (in which the mortality from cholera infantum was at the minimum) was the lowest of the years for the forty-year period (1851–90).

Distribution by Counties.

The ratios of mortality from cholera infantum by counties for the twenty-year period (1871–90) were as follows, with the number of deaths from this cause in each: —

COUNTIES.	Number of Deaths from Cholera Infantum.	Ratio per 10,000 of the Population.	Ratio per 10,000 of the Population under 5 Years.
Barnstable,	228	3.57	41.4
Berkshire,	1,312	9.50	82.3
Bristol,	4,408	15.85	147.0
Dukes,	34	3.95	64.0
Essex,	5,575	11.40	118.0
Franklin,	459	6.37	65.7
Hampden,	2,851	13.68	127.7
Hampshire,	813	8.60	93.7
Middlesex,	8,288	13.05	124.8
Nantucket,	30	4.02	64.5
Norfolk,	1,549	8.02	80.7
Plymouth,	1,033	6.98	75.0
Suffolk,	10,907	14.06	138.3
Worcester,	4,928	10.86	100.0
THE STATE,	42,375	11.88	116.8

The extremes were Bristol County, with a ratio of 15.85 per 10,000 of the total population, or 147 per 10,000 of the population of children under 5 years; and Barnstable County, with a ratio of 3.57 per 10,000 of the population at large, or 64 per 10,000 of the children living under 5 years of age. When compared with the living population under 5 years, Dukes, Nantucket and Franklin counties had nearly identical and low ratios of mortality.

Relation to Density of Population.

In the following tables the relation of the mortality from cholera infantum to the density of population is clearly shown. The same arrangement is employed as in the other diseases which are treated of in this paper: —

Counties of Massachusetts arranged according to their Death Rates from Cholera Infantum (1871–90), that of the State being taken as 100, the Density of Population expressed in Acres to Each Living Person.

COUNTIES.	Density of Population. Acres to Each Person.	Mortality Rank.	Mortality Rank, Children under 5.	Birth Rate Average of 5 Census Years, 1870, '75, '80, '85, '90.
Barnstable,	7.5	30	35	18.22
Dukes,	18.4	33	55	15.63
Nantucket,	11.2	34	55	14.14
Franklin,	11.8	54	56	19.47
Plymouth,	5.9	59	64	19.74
Norfolk,	3.3	67	69	23.50
Hampshire,	7.7	72	80	21.39
Berkshire,	8.9	80	70	25.02
Worcester,	4.4	91	86	25.61
Essex,	1.3	96	101	23.96
THE STATE,	**2.9**	**100**	**100**	**25.68**
Middlesex,	1.7	110	107	25.66
Hampden,	3.9	115	109	28.08
Suffolk,	.07	118	118	29.79
Bristol,	2.5	133	126	26.22

The relation of density of population to the mortality from cholera infantum is not only shown in the foregoing table but also in the following, in which the counties are divided into three groups, arranged, as in the other diseases, according to their density: —

Counties grouped according to their Density of Population.	COUNTIES.	Acres to Each Person.		Mortality Rank from Cholera Infantum, the State =100.		Compared with Children living under 5 Years of Age.
I. County in which there is less than one acre to each inhabitant,	Suffolk,	.07		118		118
II. Counties having more than one but less than four acres to each inhabitant,	Essex,	1.3	Average, 2.1.	96	Average, 106.	101
	Middlesex,	1.7		110		107
	Bristol,	2.5		133		126
	Norfolk,	3.3		67		68
	Hampden,	3.9		115		109
III. Counties having more than four acres to each inhabitant,	Worcester,	4.4	Average, 6.4.	91	Average, 75.	86
	Plymouth,	5.9		59		64
	Hampshire,	7.7		72		80
	Berkshire,	8.9		80		70
	Barnstable, Dukes and Nantucket,	9.0		30		36
	Franklin,	11.8		54		56

Stating the foregoing in a different manner: —

The mortality of *dense* districts was	1,000
The mortality of *medium* districts was	898
The mortality of *sparse* districts was	635

The difference, therefore, between the mortality of the medium and that of the dense districts was less than the difference between the mortality of the sparse and that of the medium districts.

Classification by Towns.

An examination of the extremes in the table of towns presenting the deaths from cholera infantum in each for the period of twenty years (1871–90) shows very clearly some of the principal conditions which are favorable to the prevalence of this destructive disease.

There were 7 towns in which no deaths were reported from this cause during the period in question. Five of this number (Alford, Mt. Washington, Monroe, Goshen and Plainfield) are west of the Connecticut River, and all are remote from dense centres of population. (See Map No. 6.) The remaining two (Eastham and Mashpee) are sea-coast towns upon Cape Cod. The 7 towns are all towns of small population, the entire population of the 7 being but 2,541, and the average of each 363. The ratio of children in these towns is also small. The inhabitants of the 5 western towns are chiefly farmers. Those of the 2 towns in Barnstable County are chiefly engaged in fishing and the culture of cranberries.

Still further: in the first 50 towns upon the list, including the 7 towns already named, there are only 2 towns having a population of more than 2,000 in each, and the general character and occupation of the inhabitants is much like that of the 7 towns at the head of the list. The first group of towns having a mortality from cholera infantum 50 per cent. less than that of the State embraces 171 towns, in which number are only 2 towns having a population of more than 5,000 in each, by the census of 1880. These were Plymouth and Natick.

No city appears in the list until the 229th place is reached, and this first city (Newton) can scarcely be called a city except in the number of its inhabitants. It is composed mainly of a

well-to-do and wealthy class of citizens, with a comparatively small ratio of tenement-houses or laboring people.

The next cities to appear in the list are Malden, Newburyport and Waltham.

Of the 34 cities and towns at the other extreme, 15 are cities, in each of which there is a considerable ratio of manufacturing population, living under conditions unfavorable to the welfare of young children.

At the extreme of high mortality (places having a mortality from cholera infantum more than 50 per cent. higher than that of the State) are 5 municipalities, including 4 large factory cities and 1 town of the same character.

The singularly uniform and high mortality rank of Winthrop and Belmont, towns of small population, and having comparatively favorable conditions with reference to climatic, sanitary and social circumstances, is quite remarkable, and appears to be more than a mere coincidence. During the period in question there were 59 deaths in Winthrop from cholera infantum. If all these had been credited to the town, Winthrop would have ranked highest in its mortality rate from cholera infantum except one (Fall River); but 23 of these deaths occurred at the sea-shore home for infants, and should therefore not be reckoned with those of the town.

The high mortality of Winthrop from cholera infantum is probably due to the practice of taking sick infants to this town from Boston for the benefit of a change of air, such children being already too far prostrated by the disease to admit of recovery. To similar causes may also possibly be attributed the comparatively high mortality ratio of Shrewsbury, Freetown, Somerset, Williamstown, Hatfield, South Hadley and Agawam, which are respectively near to the cities and large towns of Worcester, Fall River, North Adams, Northampton, Holyoke and Springfield.

In the following table I have also introduced a column presenting the comparative birth rate of each city, that of the State being taken as 100. By this table it appears, generally speaking, that the cities with low birth rates also had a low death rate, and conversely those having high birth rates had high death rates from cholera infantum.

The notable exceptions are Gloucester and Quincy, which

had high birth rates and low death rates from cholera infantum, while at the other extreme Lowell and Lawrence had birth rates which were but little above that of the State, but had very high death rates from cholera infantum. The seven cities having the highest death rates from cholera infantum also had birth rates higher than that of the State. The birth rates of the cities are the average birth rates of the five census years, 1870, '75, '80, '85 and '90.

Cities.

	The State = 100.			The State = 100.	
	Mortality Rank from Cholera Infantum.	Birth Rates.		Mortality Rank from Cholera Infantum.	Birth Rates.
Newton,	63	79	Pittsfield,	105	99
Malden,	68	101	Chicopee,	110	106
Newburyport,	69	89	Haverhill,	111	97
Waltham,	73	105	Somerville,	117	107
Gloucester,	75	117	Marlborough,	118	134
Brockton,	77	89	Springfield,	122	105
Taunton,	77	101	Salem,	123	8
Northampton,	84	93	Boston,	124	11
Lynn,	85	96	Worcester,	125	11
Quincy,	87	116	Cambridge,	127	114
Fitchburg,	91	101	Lawrence,	168	107
New Bedford,	92	96	Holyoke,	180	155
Chelsea,	94	100	Lowell,	185	106
Woburn,	101	119	Fall River,	228	121

Employment of Mothers away from Home. — Another point worthy of consideration is the relation of the number of married women employed in factories to the death rate from cholera infantum. In 1885 a State census was taken, in which were enumerated the number of persons employed in factories, including married women. Out of the entire population of the State in that year (1,942,141) there were 13,521 married women employed in factories. The 5 factory cities and towns standing at the extreme of high mortality from cholera infantum had a population of 193,952 in 1885, or 10 per cent. of the total population of the State; and 3,395 married women in these places were employed in factories, or 25 per cent. of all married women so employed in the State. The ratio of married women so employed in these places to the total population was 1.7 per cent., while in the State it was but seven-tenths of one per cent. The highest ratio of this class to the total population

was in Fall River (3.1 per cent., or 1,776), and this city had the highest mortality from this cause.

It is worth while to note also the ratio of married women employed in the principal industries, as compared with the whole number employed. In the manufacture of boots and shoes the number of married women employed in factories was 4 per cent. of the total number employed; in woolen manufacture it was 5.6 per cent.; in clothing manufacture it was 6.9 per cent.; in cotton manufacture it was 8.2 per cent.; in paper manufacture it was 10.4 per cent. The whole number of married women employed in these different industries was 10,782, or 80 per cent. of all married women employed in factories in the State.

In the cities in which boot and shoe manufacture is the chief industry, the cholera infantum death rate was generally less than that of the cities in which the remaining industries specified are carried on; and the three principal boot and shoe cities had mortality ratios from cholera infantum which were fairly proportionate to the ratio of married women employed in these cities. Haverhill, ranking quite high upon the list (111 as compared with the State, 100), had a ratio of married women employed which was 2.9 per cent. of its population. In Lynn, with a rank of 85, the ratio of married women so employed was 1.7 of the population. In Brockton, with a rank of 77, the ratio of married women employed was 1.4 per cent. of the population.

The bearing of these statistics upon the subject is too obvious to require further discussion. The data would have been much more complete had the ratio of these women who were mothers of young children been included in the same census.

A high mortality rate from cholera infantum occasionally exists in a comparatively small town, where there are one or more densely populated manufacturing villages in which the conditions of living may resemble those of a large city. Such towns, with high mortality rates from this cause, are Webster, Sutton, Dudley, Spencer, Ware, Adams and Millbury. Upon this point Dr. Haven says, in the paper already quoted: "We may have all, or nearly all, of the most vicious conditions of city life in a single tenement-house in some small town of perhaps only a thousand inhabitants; we may have, that is, the heat, the dirt, the overcrowding, the bad drainage and the artificial feeding, which are the concomitants of city life."

The Relation of the Milk Supply to the Mortality from Cholera Infantum.

For the past nine years the State Board of Health has effected a continuous inspection of milk in the principal cities and towns of Massachusetts, in which work the Board has endeavored to distribute the inspection with a fair degree of uniformity throughout the State. As a matter of convenience, it has been customary to divide the State into two portions, one including the four western counties, — Berkshire, Franklin, Hampshire and Hampden. In two of the years during which this inspection has been made, comparisons were made of the results of analyses in these two sections.

The number of samples of milk obtained from wagons and places where milk is sold for analysis in 1888 and 1889 was 5,895, of which 5,296 were collected in eastern Massachusetts and the remainder (599) in the four western counties. Of the former number, 43.3 per cent. were found on analysis to be below the legal standard of purity (13 per cent. of total solids), while only 16.7 per cent. of the latter were below the standard. It is impossible to say with accuracy how many of those which fell below the requirements of the statutes owed their deficiency to actual adulteration either by the dairymen or by some of the various agents through whose hands the milk passed on its way to the consumer, and in how many cases the deficiency was merely a natural result of impoverished feeding, peculiar breeds, age or other conditions. There are also other questions or conditions which seriously affect the quality of the milk supply, such as cleanliness at the place of its production, in the care of animals and their surroundings, as well as of the persons having charge of the milking and the subsequent handling of the milk. The distance and the length of time elapsing between the production of the milk and its consumption have a still further and important relation to its purity. This phase of the subject has been already mentioned in the reference to a paper upon milk supplies by Prof. W. T. Sedgwick (page 665 of this report).

A large ratio of infants are artificially reared, and the chief article of food consumed for the purpose is cow's milk. No doubt can be entertained that milk produced under unfavorable conditions constitutes a factor of prime importance in the causation of cholera infantum.

The results of analyses already stated show that the milk of eastern Massachusetts was adulterated to a degree nearly three times as great as that of western Massachusetts; and it may safely be affirmed that an average hundred samples of milk of "good standard quality," purchased at random of milkmen or in shops or markets, in any city or large town, would also in general be of better quality, so far as age, cleanliness and other favorable conditions are concerned, than another hundred samples all of which were deficient in the legal standard of requirements, and hence would be safer for use as the food of infants.

In the counties of western Massachusetts, during the six years 1885–90, only two occasions were found by the State Board of Health for prosecutions of offenders against the milk laws, while 242 such prosecutions were made in the same period in the eastern counties; the ratio, when considered in its relation to population, being twenty times as great in the eastern as in the western counties. This difference would be greatly increased if the convictions secured by city milk inspectors in Boston and its suburbs were added to the foregoing.

The mortality from cholera infantum in the four western counties, when compared with that of the eastern for the twenty years under consideration, was as 1,000 to 1,141.

This consideration of the question is not very conclusive, from the fact that there are several large cities with dense populations in the western counties (Holyoke and Springfield); while, on the other hand, there are large tracts of sparsely populated country, like Barnstable County, in eastern Massachusetts. The comparative density of the two sections of the State by census of 1890 was as 100 for the western to 355 for the eastern portion. A much better comparison would have been between the rural towns as a whole, in which very little milk, comparatively, is sold to the consumer, and the cities in which very little is produced for consumption, while the principal volume of the supply comes from a distance of from ten to one hundred miles.

An examination of the table of towns (page 840) shows that nearly all of the first two hundred towns in the list are of the former class, while the densely crowded cities are at the other extreme of high mortality from cholera infantum.

Still further, by a stricter grouping of the State into cities

and towns of dense population, in which are villages and densely settled portions, 87 in number, and the remainder being towns of comparatively sparse population, we find that the annual ratio of mortality per 10,000 of the population in the former was 13.09, and in the latter 6.21; or, stated differently, as 1,000 in the densely settled towns to 474 in the sparsely settled cities and towns.

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Cholera Infantum in Twenty Years, the State being taken as 100.

Towns in which there were no deaths from cholera infantum registered during the period 1871-90: Goshen, Mount Washington, Plainfield, Eastham, Alford, Mashpee, Monroe.

Towns in which the mortality from cholera infantum was more than fifty per cent. below the average: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Mattapoisett,	1	3	Hancock,	3	20
Ashfield,	1	4	Tyngsborough,	3	20
Ashby,	1	5	New Marlborough,	9	20
Cummington,	1	5	Pelham,	3	20
Warwick,	1	6	Chatham,	11	20
Orleans,	2	6	Pembroke,	7	21
Hawley,	1	7	Blandford,	5	21
Brewster,	2	7	Chesterfield,	4	22
Howe,	1	8	Heath,	3	22
Chilmark,	1	8	Florida,	3	22
Worthington,	2	11	Petersham,	6	23
Granby,	2	11	Harwich,	18	23
Gill,	2	11	Dartmouth,	19	23
Littleton,	3	13	Northfield,	9	23
Boxborough,	1	13	Savoy,	4	23
Greenwich,	2	13	Erving,	5	24
Yarmouth,	3	13	Rochester,	6	24
New Braintree,	2	14	Granville,	7	24
Hubbardston,	5	15	Brimfield,	7	24
Southwick,	4	15	Wellfleet,	11	25
Leyden,	2	17	Middleton,	6	25
Harvard,	5	17	Colrain,	11	26
Leverett,	3	17	Falmouth,	15	26
Washington,	2	17	Becket,	7	26
Hull,	2	18	Marion,	6	26
Charlton,	8	18	Tewksbury,	14	27
Sterling,	6	18	Sandisfield,	7	27
Charlemont,	4	18	Sheffield,	14	27
Berkley,	4	18	Wrentham,	16	27
Bolton,	4	19	Prescott,	3	27
Dunstable,	2	19	Shirley,	9	28
Newbury,	7	19	Gosnold,	1	28
Hanson,	6	19	Montgomery,	2	28
Dover,	3	19	West Bridgewater,	11	28
Tisbury,	7	19			

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Cholera Infantum, etc. — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Tolland,	3	28	Royalston,	11	39
Cottage City,	3	28	Sunderland,	7	39
New Salem,	6	29	Middlefield,	6	39
Groton,	13	29	Wellesley,	14	39
Burlington,	5	30	Pepperell,	22	39
Acushnet,	8	30	Stockbridge,	22	39
Duxbury,	16	31	Lanesborough,	12	39
Medfield,	10	31	Westford,	20	39
Rehoboth,	14	31	Boylston,	8	39
Rowley,	9	31	Georgetown,	21	39
Reading,	24	32	Bridgewater,	34	39
Otis,	6	32	Southampton,	10	40
Topsfield,	9	32	Hingham,	43	40
Huntington,	17	33	Bernardston,	9	41
Foxborough,	23	33	Phillipston,	6	41
Marshfield,	14	33	Uxbridge,	30	41
Lakeville,	8	33	Natick,	82	41
Westport,	23	33	Saugus,	27	41
Wilbraham,	13	34	Amherst,	42	41
Barnstable,	34	34	New Ashford,	2	41
Oakham,	7	34	Merrimac,	16	41
Norton,	14	34	Holland,	3	42
Princeton,	9	34	East Bridgewater,	27	42
Nantucket,	30	34	Ashburnham,	21	43
Dennis,	27	35	Paxton,	6	43
Weston,	12	35	Egremont,	9	43
Upton,	17	35	Cheshire,	16	44
Essex,	14	35	Shelburne,	17	44
Sandwich,	30	36	Melrose,	56	44
Westminster,	14	36	North Andover,	34	44
Conway,	15	36	Acton,	19	44
Boxford,	7	36	Hanover,	20	44
Kingston,	13	36	Norfolk,	10	45
Belchertown,	20	36	Monson,	41	46
West Newbury,	17	36	Lunenburg,	12	46
Hamilton,	8	36	West Stockbridge,	21	46
Sherborn,	12	36	Mendon,	12	46
Carver,	9	36	Lancaster,	22	46
Plympton,	6	36	Billerica,	22	46
Franklin,	35	36	Cohasset,	24	46
Nahant,	7	36	Tyringham,	6	46
Wales,	9	37	Raynham,	19	47
Lynnfield,	6	37	Stow,	12	48
Norwell,	16	37	Fairhaven,	83	48
Blackstone,	43	37	Plymouth,	83	49
Richmond,	10	37	Salisbury,	48	49
Norwood,	23	38	Holbrook,	24	50
Halifax,	5	39	Mansfield,	34	50

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Cholera Infantum, etc. — Continued.

Cities and towns in which the mortality from cholera infantum was below the average but not fifty per cent. below it: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Hardwick,	27	51	Barre,	35	61
Townsend,	24	51	Hopkinton,	67	61
Dana,	9	51	Scituate,	36	61
Berlin,	12	52	Rockland,	58	62
Dedham,	77	52	Deerfield,	52	62
Wenham,	11	52	Templeton,	41	62
Lenox,	27	52	Truro,	15	62
Gay Head,	2	52	Swanzey,	20	62
Walpole,	31	52	Williamsburg,	33	62
Peru,	5	52	Orange,	47	62
Westhampton,	7	52	Lexington,	39	62
Provincetown,	54	52	NEWTON,	268	63
Windsor,	8	52	Chester,	22	63
Dracut,	20	53	Rutland,	16	63
Monterey,	8	53	Needham,	58	64
Buckland,	22	53	Clarksburg,	11	64
Dighton,	23	54	Brookfield,	43	64
Medway,	51	54	Chelmsford,	39	64
Stoughton,	63	54	Milford,	144	65
Andover,	67	54	Wareham,	45	65
Leicester,	36	54	Greenfield,	66	66
Middleborough,	68	55	Holden,	39	66
Whately,	14	55	West Brookfield,	30	66
Seekonk,	16	55	Manchester,	26	67
Ludlow,	20	55	Southborough,	34	67
Leominster,	72	55	Swampscott,	40	67
Randolph,	53	55	Sudbury,	19	68
Wakefield,	74	55	MALDEN,	225	68
Hadley,	26	56	NEWBURYPORT,	221	69
Carlisle,	7	57	Bellingham,	20	69
Rockport,	53	57	Winchendon,	61	69
Framingham,	92	57	Easthampton,	69	69
Warren,	53	57	Groveland,	37	70
Longmeadow,	22	57	Athol,	77	70
Auburn,	18	57	Medford,	135	71
Wayland,	27	58	Ayer,	32	71
Concord,	54	58	Bradford,	47	71
Palmer,	76	58	Weymouth,	180	72
Hampden,	8	58	Ashland,	41	72
Great Barrington,	65	59	Wendell,	8	72
Bedford,	13	59	Enfield,	18	73
Canton,	64	60	Ipswich,	64	73
Lincoln,	13	60	WALTHAM,	222	73
Edgartown,	20	61	Brookline,	149	73
Hinsdale,	23	61	Oxford,	46	74
North Reading,	13	61	Easton,	69	74

Cities and Towns of Massachusetts arranged in the Order of their Death Rates from Cholera Infantum, etc — Concluded.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Holliston, ...	55	75	Southbridge, . . .	130	85
GLOUCESTER, . . .	347	75	LYNN, ...	807	85
Winchester, . . .	68	75	Grafton, ...	81	85
Dalton, ...	37	76	North Brookfield, . .	90	85
Danvers, ...	119	76	Sturbridge, . . .	42	86
Whitman, ...	49	76	West Boylston, . .	62	87
Beverly, ...	154	77	QUINCY, ...	232	87
Russell, ...	15	77	Amesbury, . . .	107	87
Westborough, . . .	95	77	North Adams, . .	178	89
BROCKTON, ...	293	77	Hyde Park, . . .	153	89
TAUNTON, ...	400	77	Revere, ...	61	89
Shrewsbury, . . .	28	78	Wilmington, . . .	20	90
Methuen, ...	82	78	FITCHBURG, . . .	319	91
Freetown, ...	25	79	NEW BEDFORD, . .	651	92
Milton, ...	62	79	CHELSEA, ...	510	94
Sharon, ...	28	79	Marblehead, . . .	167	94
Shutesbury, . . .	1	79	Peabody, ...	198	94
Stoneham, ...	93	80	Williamstown, . .	84	95
Lee, ...	75	80	Attleborough, . .	251	95
Northbridge, . . .	79	82	Somerset, ...	46	96
Everett, ...	105	82	Clinton, ...	182	97
Watertown, . . .	110	82	Hudson, ...	86	97
Westfield, ...	162	83	Braintree, ...	96	97
NORTHAMPTON, . .	245	84	Hatfield, ...	35	98
Maynard, ...	46	84	**THE STATE**, . .	42,375	100

Cities and towns in which the mortality from cholera infantum was above the average but not fifty per cent. above it: —

Douglas, ...	54	101	SOMERVILLE, . . .	730	117
WOBURN, ...	262	101	MARLBOROUGH, . .	289	118
Agawam, ...	55	104	Winthrop, ...	36	120
PITTSFIELD, . . .	342	105	Belmont, ...	47	122
Arlington, ...	103	106	SPRINGFIELD, . .	1,006	122
Abington, ...	93	106	SALEM, ...	799	123
Millbury, ...	120	106	BOSTON, ...	10,588	124
Northborough, . .	43	108	WORCESTER, . . .	1,788	125
Gardner, ...	145	110	Ware, ...	160	127
CHICOPEE, ...	295	110	CAMBRIDGE, . . .	1,627	127
West Springfield, . .	110	111	Spencer, ...	227	128
HAVERHILL, . . .	504	111	South Hadley, . .	108	128
Sutton, ...	84	114	Dudley, ...	89	134
Adams, ...	281	117	Montague, ...	152	143

Cities and towns in which the mortality from cholera infantum was more than fifty per cent. above the average: —

Webster, ...	223	165	LOWELL, ...	2,535	185
LAWRENCE, ...	1,489	168	FALL RIVER, . . .	2,739	228
HOLYOKE, ...	963	180			

Consumption.

More deaths annually occur in Massachusetts from phthisis or consumption than from any other cause. In the twenty years (1871–90) the whole number of deaths which were reported in the State from this cause was 112,604, which was 15.7 per cent. of the number of deaths from all causes combined, and was also equivalent to an average annual mortality rate of 31.6 per 10,000 of the living population.

The annual mortality attributed to this cause for each year of the period was as follows: —

YEARS.	Death Rate per 10,000 from Consumption.	YEARS.	Death Rate per 10,000 from Consumption.
1871,	33.9	1881,	32.4
1872,	36.2	1882,	31.7
1873,	35.3	1883,	31.5
1874,	32.8	1884,	30.3
1875,	34.7	1885,	30.7
1876,	32.2	1886,	29.5
1877,	32.9	1887,	28.5
1878,	32.0	1888,	27.1
1879,	30.4	1889,	25.7
1880,	30.8	1890,	25.9
Average, 1871-80,	32.7	Average, 1881-90,	29.2
Average of the twenty years,			31.6

From this table it appears that there has been a considerable reduction in the mortality rate from this cause, when the two successive decades are compared, the reduction amounting to 3.5 per 10,000, or a little more than 10 per cent. of the average mortality rate for twenty years.

Distribution by Counties.

The ratio of mortality per 10,000 of the living population was as follows, by counties, for the twenty-year period (1871–90): —

COUNTIES.	Deaths from Phthisis.	Ratio per 10,000 of the Population.
Barnstable,	2,108	33.0
Berkshire,	3,276	23.7
Bristol,	8,704	31.3
Dukes,	225	26.2
Essex,	15,615	31.9
Franklin,	1,808	25.1
Hampden,	5,935	28.5
Hampshire,	2,573	27.2
Middlesex,	20,177	31.7
Nantucket,	338	45.3
Norfolk,	5,150	26.7
Plymouth,	4,421	29.8
Suffolk,	29,581	38.1
Worcester,	12,693	28.0
THE STATE,	112,604	31.6

The extremes of mortality were Nantucket, with a ratio of 45.3 per 10,000, and Berkshire, with 23.7.

Density of Population.

The relation of the mortality from consumption to the density of population is shown in the following table, in which the State is taken as an average or standard of comparison : —

Counties of Massachusetts arranged according to their Death Rates from Phthisis (1871-90), that of the State being taken as 100, the Density of Population expressed in Acres to Each Living Person.

COUNTIES.	Density of Population, Acres to Each Person.	Mortality Rank from Phthisis, the State = 100.
Berkshire,	8.9	75
Franklin,	11.8	79
Dukes,	1.4	83
Norfolk,	3.3	84
Hampshire,	7.7	86
Worcester,	4.4	89
Hampden,	3.9	90
Plymouth,	5.9	95
Bristol,	2.5	99
THE STATE,	2.9	100
Middlesex,	1.7	100.5
Essex,	1.3	101
Barnstable,	7.5	104
Suffolk,	.07	121
Nantucket,	11.2	144

In the following table the counties are still further arranged or classified in groups, according to their density of population, an opportunity being thus presented of comparing the averages of each group with the mortality from phthisis: —

Counties grouped according to their Density of Population.	Counties.	Acres to Each Person.		Mortality Rank from Phthisis.	
I. County in which there is less than one acre to each person,	Suffolk,	.07		121	
II. Counties having more than one acre but less than four acres to each person,	Essex,	1.3	Average, 2.1.	101	Average, 98.
	Middlesex,	1.7		100.5	
	Bristol,	2.5		99	
	Norfolk,	3.3		84	
	Hampden,	3.9		90	
III. Counties having more than four acres to each person,	Worcester,	4.4	Average, 6.4.	89	Average, 88.
	Plymouth,	5.9		95	
	Hampshire,	7.7		86	
	Berkshire,	7.5		75	
	Barnstable, Dukes and Nantucket,	9.0		106	
	Franklin,	11.8		79	

By the foregoing it appears that the mortality from phthisis, when large groups are considered, bears a tolerably definite relation to the density of population. By a further division, it appears that the mortality from phthisis in Massachusetts diminishes in its ratio to the distance from the sea-coast. Dividing the State counties into the following groups, the mortality for phthisis was as follows: —

Groups.	Annual Ratio of Mortality from Phthisis per 10,000 of Population.
1. All of the sea-coast counties except Suffolk,	31.1
2. Worcester County,	27.9
3. The Connecticut River counties,	27.5
4. Berkshire County,	23.7

Nantucket, at the extreme east, and with an insular climate, had a ratio of 45.3. I have excepted Suffolk County from the foregoing list, for the reason that its excessive density of pop-

ulation and the existence in Boston of several large hospitals and places where consumptives are received as patients may be considered as having much greater influence than geographical position upon the phthisis death rate. Admitting Suffolk County to the list, with its mortality ratio of 38.1, the mortality rate of the group thus constituted would be 33.1.

If we assume the mortality from phthisis in the western county (Berkshire) as 1,000, that of the Connecticut valley counties was 1,160; that of Worcester County was 1,177; that of the sea-coast counties (except Suffolk) was 1,312; that of Suffolk was 1,608; that of Nantucket was 1,911.

A similar observation was made by Dr. H. I. Bowditch, in his paper entitled "Consumption in Massachusetts," and at a later date it was also very clearly shown by Dr. W. Everett Smith, in another paper before the Massachusetts Medical Society in 1888.

Being desirous of ascertaining to what extent, if any, this decrease is manifested in a westerly direction, I wrote to the secretary of the State Board of Health of New York, asking information upon the subject; and he replied that "it has always been evident that the relative mortality from consumption has been highest by far in the maritime district. The Hudson Valley district is next, and third in the series I think is the Lake Ontario and western district. It is to be noted that these are districts of high urban population."

Classification by Towns.

In examining the list of cities and towns, the 10 towns having the lowest ratios upon the list are all small towns, having an average population in each of but 828. Three only had more than 1,000 inhabitants in each. Four of the number are Berkshire towns. New Ashford, lowest in rank, is a small town of 203 inhabitants (census of 1880), upon very high land, south-west of Mt. Greylock, the highest land in the State. It has a population devoted almost exclusively to farming. Dunstable, Littleton and Burlington are three farming towns of small population, situated in northern Middlesex, and not far apart. Their inhabited portions are mostly high and dry. Nahant, Revere and Winthrop are three nearly contiguous towns upon the sea-coast, each having a resident

and transient summer population of considerable size, in addition to the permanent population.

Of the 32 towns in Berkshire, 7 held positions more than fifty per cent. lower than the average of the State in their mortality from consumption, and only 1 of the number, the small town of Alford, had a death rate from this cause which was higher than that of the State.

There was not one town in the State in which there was no death from consumption in the twenty years, and the number of deaths ranged from 2 only in New Ashford up to 28,666 in Boston.

The first city to appear in the list is Newton, ranking as 60 (the State being 100), and followed by other cities in the following order: —

Newton,	60	Chelsea,	92	Salem,	103
Pittsfield,	75	Holyoke,	92	Lynn,	104
Gloucester,	82	Woburn,	93	New Bedford,	105
Quincy,	82	Taunton,	94	Fall River,	107
Fitchburg,	83	Brockton,	94	Chicopee,	113
Malden,	86	Cambridge,	94	Lowell,	114
Springfield,	89	Marlborough,	96	Newburyport,	114
Somerville,	89	Northampton,	97	Lawrence,	122
Worcester,	90	Haverhill,	98	Boston,	127
Waltham,	91				

At the other extreme, the two small Indian towns of Gay Head and Mashpee only had phthisis death rates more than fifty per cent. higher than the average.

Out of the 14 towns of which Barnstable County was comprised at the beginning of the period (1871–90), 9 are to be found among those having a mortality rate from phthisis as great as or greater than that of the State at large.

Of the 58 cities and towns which had high ratios (higher than those of the State), 36 were in the sea-coast and island counties of Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Dukes and Nantucket. These 36 towns contained over 85 per cent. of the population of the group of 58. Nineteen out of this number are situated immediately upon the sea-coast.

The only cities and large towns having high ratios of mortality from phthisis, and also located at a considerable distance from the sea-coast, are Lowell, Chicopee, Ware and Milford.

A similar tabulation was made in 1865 by Dr. Geo. Derby, afterward secretary of the State Board of Health. This table included a period of ten years, none of which were within the time of the present inquiry. These were the ten years 1856–65. From this table I copy the 25 towns at the two extremes of greatest and least mortality: —

Rank, the State =100.	Least Mortality (Ten Years, 1856-65), beginning with the Towns having the Least Mortality.	Ratio per 10,000.	Rank, the State =100.	Greatest Mortality (Ten Years, 1856-65), ending with the Towns having the Greatest Mortality.	Ratio per 10,000.
17	Mount Washington,	6.2	121	Harwich,	45.2
23	Monroe,	8.5	122	Pepperell,	45.5
25	Clarksburg,	9.5	122	Hanover,	45.5
26	Revere,	9.7	122	Lunenburg,	45.5
28	Nahant,	10.5	124	LAWRENCE,	46.3
32	Cheshire,	11.8	125	Ware,	46.7
33	Hancock,	12.2	125	Ashby,	46.7
35	Weston,	12.9	126	West Newbury,	47.2
35	Rowe,	12.9	128	Chesterfield,	47.8
35	Windsor,	13.1	128	Enfield,	47.8
35	Richmond,	13.1	128	Tyngsborough,	47.8
37	Chester,	13.7	128	Royalston,	47.8
40	Chelmsford,	14.9	129	Millbury,	48.1
41	Belmont,	15.5	129	Salisbury,	48.3
43	Middleton,	16.0	130	Rockport,	48.5
44	Auburn,	16.4	131	Wales,	48.8
44	Becket,	16.4	131	Oakham,	49.0
45	New Ashford,	16.7	133	Russell,	49.5
45	Otis,	17.0	133	Northfield,	49.7
47	West Roxbury,	17.7	135	Chatham,	50.3
49	Chilmark,	18.3	140	FALL RIVER,	52.3
50	Alford,	18.5	142	Orleans,	52.9
51	Edgartown,	18.9	143	Wenham,	53.5
51	Tewksbury,	18.9	144	Upton,	53.7
51	Holland,	19.1	145	Randolph,	54.3
	100, THE STATE,				3.73

In the foregoing lists of towns having high and low mortality from consumption we find that 13 towns in the list of low mortality are west of the Connecticut River. Twenty-three out of the 25 continued to have low or comparatively low ratios in the later period, and among these Nahant, Weston, Richmond and New Ashford retained positions quite near the minimum in both periods. Alford was the only town having a low rank in the earlier list which changed its position to a high rank in the later.

In the lists of towns having high mortality from consumption the names of Randolph, Chatham and Orleans appear in both groups, while Fall River, Ware and Rockport appear in the former list, and also have comparatively high positions in the later list. The two small towns of Wales and Oakham show a very marked improvement, having been the 9th and 10th in point of high mortality in the earlier list, while in the later list (1871–90) Wales appears among the 20 towns having lowest mortality, and Oakham has a comparatively low position. The towns of Upton, Northfield, Russell, Salisbury, Millbury, Royalston, Tyngsborough, Enfield, Chesterfield, West Newbury, Ashby, Pepperell and Lunenburg changed their position from a high to a comparatively low rank.

Among the cities, Newton maintains a very low rank in each table, and Holyoke, which was a small town in the earlier period, was lowest in the earlier list but has an intermediate place in the later table.

In the earlier table Fall River was the only city among the 20 places having the highest mortality from phthisis, but in the later list Boston appears among the 20 highest as the city having highest ratio of mortality from phthisis; while Lawrence, Newburyport, Lowell and Chicopee follow in the order named, and Fall River takes a lower position than either of these.

It would have been an extremely interesting inquiry to have carried out in this paper the same line of investigation pursued in Dr. Bowditch's address in 1862, in which he published his doctrine of soil moisture as a cause or favoring condition for the development of phthisis. Such an investigation, however, would have been impossible within the limits of this paper, since it would have required the obtaining of facts relative to the residence of each of the 112,000 persons who were reported to have died of consumption in this period of twenty years.

Another doctrine in which Dr. Bowditch expressed his belief quite strongly at later periods was the infectiousness of consumption (see papers in "Atlantic Monthly," Vol. 23, page 179, 1869; and "Boston Medical and Surgical Journal," 1864, article "Is consumption ever contagious?"), which appears to

be confirmed by the present inquiry; that is to say, phthisis reaches its highest ratio of mortality in the most densely settled districts of the State, in the following ratio: —

Mortality of dense districts,	1,000
Mortality of medium districts,	810
Mortality of sparse districts,	727

This appears to be the general characteristic of all infectious diseases, independent of other conditions, and is plainly one result of the nearness with which people suffering from infectious diseases are brought to each other, as was clearly shown by Dr. Farr.

Another condition favorable to the development of phthisis is location at a low level as compared with the level of the sea. Berkshire, Franklin and the other western counties, having low ratios of mortality from this cause, are all at elevations much higher than the sea-coast counties. This observation is borne out by the experience of many who seek the elevated regions of Colorado and Minnesota for the relief which they there find (see papers by Dr. F. I. Knight, American Climatological Association, 1890; also "A people without consumption," and "The Cumberland tableland," Dr. E. M. Wright, 1876).

Consumption.

Towns in which the mortality from consumption was more than fifty per cent. below that of the State: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
New Ashford,	2	16	Wendell,	13	44
Dunstable,	10	35	Boxborough,	9	45
Littleton,	22	35	Winthrop,	86	45
Richmond,	25	35	Sandisfield,	32	46
Nahant,	20	39	New Marlborough,	55	46
Burlington,	18	40	Washington,	15	48
Lanesborough,	33	41	Plainfield,	14	48
Peru,	11	43	Wales,	32	49
Hamilton,	26	44	Southwick,	35	50
Mattapoisett,	38	44			

Cities and towns in which the mortality was below that of the State but not fifty per cent. below it: —

Weston,	47	51	Pelham,	20	52
Lenox,	71	52	Revere,	94	52

Consumption — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Lincoln,	30	52	West Brookfield,	79	65
Montgomery,	10	52	Wayland,	81	65
Charlemont,	31	53	Prescott,	19	65
Erving,	29	53	Hinsdale,	66	65
Heath,	19	54	Needham,	158	66
Rowley,	41	54	Sutton,	129	66
Mount Washington,	7	54	Sturbridge,	86	66
Hancock,	22	54	Shirley,	57	66
Bolton,	31	54	Princeton,	46	66
Acushnet,	38	54	Shrewsbury,	63	66
Otis,	27	54	Medfield,	58	67
New Braintree,	21	54	Seekonk,	52	67
Florida,	25	55	Sterling,	60	67
Clarksburg,	25	55	Chilmark,	21	67
Sherborn,	49	55	Norwood,	109	68
Egremont,	31	56	Athol,	197	68
Norfolk,	33	56	Groton,	80	68
Tewksbury,	78	57	Middlefield,	28	68
Brookline,	806	57	Franklin,	176	69
Rowe,	18	57	Bridgewater,	159	69
Great Barrington,	169	57	Tisbury,	66	69
Northborough,	61	58	Swampscott,	109	69
Holland,	11	58	Gill,	32	69
Enfield,	39	59	Melrose,	232	69
Bellingham,	46	60	Dalton,	90	69
NEWTON,	679	60	Warren,	171	70
Lakeville,	38	60	Mansfield,	125	70
Hatfield,	57	60	Kingston,	67	70
Whately,	41	60	Dartmouth,	151	70
Cummington,	34	61	Monterey,	28	70
Topsfield,	45	61	Charlton,	84	70
Windsor,	25	61	Holden,	111	70
Wrentham,	97	62	South Hadley,	157	70
West Newbury,	78	62	Dudley,	125	71
Gosnold,	6	62	Ludlow,	68	71
Stockbridge,	93	62	Attleborough,	496	71
Newbury,	62	63	Granville,	54	71
Salisbury,	162	63	Brimfield,	54	71
Blandford,	39	63	Oakham,	39	71
Berkley,	37	63	Sunderland,	34	71
Milton,	132	63	Bedford,	42	71
Concord,	157	63	Leyden,	23	72
West Stockbridge,	77	63	Monson,	171	72
Shelburne,	65	63	Hawley,	27	72
Phillipston,	25	64	Hull,	22	73
Cohasset,	88	64	Goshen,	15	73
Sheffield,	89	64	Longmeadow,	74	73
Billerica,	81	64	Lancaster,	92	73
Colrain,	73	65	Barre,	111	73

Consumption — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Tyringham, ...	25	73	Winchendon, ...	188	80
Medford, ...	370	73	Warwick, ...	36	80
Williamstown, . . .	172	73	Raynham, ...	85	80
Greenfield, ...	196	73	Whitman, ...	137	80
Dracut, ...	74	73	Auburn, ...	67	80
Granby, ...	35	74	Tolland, ...	23	81
Wellesley, ...	70	74	Agawam, ...	113	81
Williamsburg, . . .	104	74	Middleton, ...	53	81
Norton, ...	81	74	Leominster, ...	280	81
Holbrook, ...	95	74	Pepperell, ...	121	81
Orange, ...	149	74	Dedham, ...	319	81
Southborough, . . .	101	75	Manchester, ...	84	81
PITTSFIELD, ...	646	75	Framingham, ...	347	81
Rutland, ...	50	75	Ashby, ...	47	81
Swanzey, ...	64	75	Westborough, . . .	269	82
Paxton, ...	28	75	Norwell, ...	94	82
Easton, ...	185	75	Wenham, ...	46	82
Amherst, ...	205	75	Westford, ...	111	82
Arlington, ...	196	76	GLOUCESTER, . . .	1,011	82
Duxbury, ...	105	76	Lunenburg, ...	57	82
Plymouth, ...	339	76	Hyde Park, ...	374	82
Saugus, ...	134	76	Easthampton, . . .	218	82
Natick, ...	410	76	Townsend, ...	102	82
Conway, ...	85	76	North Andover, . . .	167	82
Upton, ...	98	77	Dighton, ...	93	82
Lee, ...	191	77	Carver, ...	54	82
Watertown, ...	274	77	Belmont, ...	84	82
Winchester, ...	185	77	QUINCY, ...	6̇18	82
Rehoboth, ...	92	77	Ashland, ...	125	83
Middleborough, . . .	255	77	Hingham, ...	235	83
North Adams, . . .	410	77	Lynnfield, ...	36	83
Southampton, . . .	51	77	FITCHBURG, ...	771	83
Tyngsborough, . . .	31	78	Stow, ...	55	83
Westfield, ...	406	78	Boylston, ...	45	83
Cheshire, ...	76	78	Yarmouth, ...	115	84
Scituate, ...	122	78	Westport, ...	154	84
West Springfield, . .	206	79	Petersham, ...	59	84
Chelmsford, ...	127	79	Maynard, ...	122	84
Carlisle, ...	26	79	Ashburnham, ...	110	85
Boxford, ...	41	79	Ashfield, ...	57	85
Halifax, ...	27	79	Bernardston, ...	50	85
East Bridgewater, . .	135	79	Gardner, ...	298	85
North Reading, . . .	45	79	Spencer, ...	403	85
Hadley, ...	97	79	Leverett, ...	40	85
Truro, ...	51	79	Lexington, ...	142	85
Hardwick, ...	112	79	Uxbridge, ...	168	85
Templeton, ...	140	79	Worthington, ...	41	86
Harvard, ...	63	80	Northbridge, ...	219	86
Savoy, ...	36	80	MALDEN, ...	753	86

Consumption — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Medway, ...	214	86	Eastham, . . .	40	91
Monroe, ...	11	86	CHELSEA, . . .	1,326	92
Foxborough, . . .	160	86	Merrimac, . . .	94	92
Chester, ...	80	86	HOLYOKE, . . .	1,304	92
Reading, ...	173	86	Deerfield, . . .	206	92
Buckland, . . .	95	86	Blackstone, . . .	286	92
Russell, ...	45	87	Weymouth, . . .	618	93
Grafton, ...	221	87	Braintree, . . .	244	93
West Boylston, . .	165	87	North Brookfield, . .	261	93
Dover, ...	36	87	Westhampton, . .	33	93
Berlin, ...	54	87	New Salem, . . .	51	93
Beverly, ...	470	88	Wilmington, . . .	55	93
Wareham, . . .	161	88	WOBURN, . . .	640	93
Westminster, . . .	92	88	Rochester, . . .	62	94
SPRINGFIELD, . . .	1,934	89	TAUNTON, . . .	1,302	94
Palmer, ...	308	89	Royalston, . . .	71	94
Fairhaven, . . .	161	89	BROCKTON, . . .	954	94
Provincetown, . . .	244	89	Peabody, . . .	526	94
SOMERVILLE, . . .	1,478	89	CAMBRIDGE, . . .	3,222	94
Edgartown, . . .	32	89	Walpole, . . .	149	95
Canton, ...	254	89	Belchertown, . . .	140	95
Pembroke, . . .	79	89	Methuen, . . .	263	95
Wakefield, . . .	316	89	Cottage City, . . .	27	95
Marion, ...	54	89	Wilbraham, . . .	98	95
Hanson, ...	74	89	Clinton, ...	478	96
WORCESTER, . . .	3,419	90	Essex, ...	101	96
Webster, ...	324	90	Northfield, . . .	97	96
Barnstable, . . .	241	90	Somerset, . . .	122	96
Millbury, ...	270	90	MARLBOROUGH, . .	631	96
Southbridge, . . .	368	90	Dana, ...	45	97
Becket, ...	64	90	Mendon, ...	67	97
Chesterfield, . . .	44	91	NORTHAMPTON, . .	753	97
Marshfield, . . .	102	91	HAVERHILL, . . .	1,182	98
Adams, ...	580	91	Andover, . . .	321	98
Ayer, ...	108	91	Hampden, . . .	36	99
WALTHAM, . . .	737	91	THE STATE, . .	112,604	100

Cities and towns in which the mortality from consumption was above that of the State but not fifty per cent above it: —

Brewster, ...	72	100	Sudbury, . . .	75	101
Sharon, ...	94	100	Brookfield, . . .	181	102
Hudson, . . .	236	100	Groveland, . . .	148	102
Huntington, . . .	78	100	Montague, . . .	288	102
Greenwich, . . .	40	100	Hopkinton, . . .	298	102
Freetown, . . .	84	100	Bradford, . . .	179	102
Sandwich, . . .	225	100	Amesbury, . . .	334	103
Rockport, . . .	249	101	Hanover, . . .	124	103

Consumption — Concluded.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
SALEM, ...	1,768	103	Rockland, . . .	276	111
LYNN, ...	2,638	104	Stoughton, . . .	346	112
Ashburnham, . . .	110	104	Randolph, . . .	289	113
Everett, ...	249	150	Acton, ...	128	131
Plympton, . . .	46	105	CHICOPEE, . . .	804	113
Georgetown, . . .	148	105	LOWELL, ...	4,148	114
NEW BEDFORD, . .	1,967	105	Abington, . . .	267	114
Hubbardston, . . .	92	105	NEWBURYPORT, . .	979	114
Oxford, ...	173	105	Orleans, ...	94	115
Stoneham, . . .	325	105	Ipswich, ...	272	116
Ware, ...	351	106	Douglas, ...	166	117
Marblehead, . . .	501	106	Chatham, . . .	170	120
West Bridgewater, . .	112	106	Shutesbury, . . .	40	120
FALL RIVER, . . .	3,415	107	Milford, ...	710	121
Falmouth, . . .	167	109	LAWRENCE, . . .	2,871	122
Alford, ...	24	109	Wellfleet, . . .	146	123
Holliston, ...	214	109	BOSTON, ...	28,666	127
Leicester, ...	193	110	Dennis, ...	270	130
Harwich, ...	227	110	Nantucket, . . .	338	144
Danvers, ...	461	111			

Towns in which the mortality from consumption was more than fifty per cent. above that of the State: —

Mashpee, ...	38	174	Gay Head, . . .	29	285

PNEUMONIA.

The number of registered deaths from pneumonia in Massachusetts for the twenty-year period (1871–90) was 56,474, or 7.9 per cent. of the mortality from all causes in the same period. It was also equivalent to an annual mortality rate of 15 8 per 10,000 of the living population.

The annual mortality attributed to this cause for each year of the period was as follows: —

YEARS.	Ratio per 10,000.	YEARS.	Ratio per 10,000.
1871,	12.4	1881,	16.3
1872,	14.9	1882,	15.8
1873,	13.3	1883,	16.2
1874,	14.8	1884,	13.8
1875,	17.8	1885,	17.8
1876,	14.7	1886,	14.3
1877,	11.8	1887,	16.6
1878,	13.0	1888,	18.2
1879,	15.4	1889,	15.8
1880,	16.1	1890,	18.0
Average, ten years (1871-80),	14.6	Average, ten years (1881-90),	16.2
Average, twenty years,			15.8

Comparing the two decades, 1871–80 and 1881–90, there was a slight increase in the mortality rate from pneumonia during the whole period of twenty years.

Distribution by Counties.

The number of deaths from pneumonia in each county, and the annual ratio of mortality per 10,000 of the population in each for the period under consideration, were as follows: —

COUNTIES.	Deaths from Pneumonia, (1871-90).	Mortality Rate per 10,000.
Barnstable,	789	11.6
Berkshire,	2,299	16.6
Bristol,	3,981	14.3
Dukes,	93	10.8
Essex,	7,224	14.8
Franklin,	1,178	16.4
Hampden,	3,401	16.3
Hampshire,	1,501	15.9
Middlesex,	9,909	15.6
Nantucket,	72	9.7
Norfolk,	2,534	13.1
Plymouth,	1,722	11.6
Suffolk,	14,737	19.0
Worcester,	7,084	15.6
THE STATE,	56,474	15.8

The extremes were Nantucket, 9.7, and Suffolk, 19.0.

An examination of the foregoing table shows, first, a remarkable uniformity in the mortality rates of the more populous counties, as compared with the averages of the whole State; and, second, a progressive increase in the rate in proportion to the distance from the sea-coast. By a grouping similar to that which I have made under the head of phthisis, into four groups from east to west, we find the following results: —

1.	All of the eastern counties except Suffolk,	14.4
2.	Worcester County,	15.6
3.	The Connecticut River counties,	16.2
4.	Berkshire County,	16.6

Nantucket, at the extreme east, had a mortality rate from this cause of only 9.7 per 10,000; while that of Berkshire, at the extreme west, was 16.6. Estimating the sea-coast counties, or those having a very considerable portion of their population exposed to a maritime climate, separately (Essex, Plymouth, Barnstable, Dukes and Nantucket), their combined ratio was but 13.7.

Assuming the mortality rate of Berkshire from pneumonia as 1,000, that of the Connecticut River counties was 976; that of Worcester County was 940; that of the eastern counties was 867 (that of the sea-coast or maritime counties, considered as a group, was but 825).

I have here again excepted the metropolitan district of Suffolk, in which the extreme density of population and the presence of several hospitals have undoubtedly overbalanced the other condition of geographical position.

If the whole State is grouped into two portions, one including all the cities and manufacturing towns (87 in number) and the other all the remaining or agricultural towns, the effect of density is shown to be but a slight one, since the former had a mortality ratio from this cause of 15.6 per 10,000, and the latter 14.1 per 10,000. If the city of Boston is excepted from the former group, its ratio when thus diminished amounted to only 14.7.

Adopting now the arrangement pursued with the other diseases, the table is as follows, by counties arranged according to their mortality rank from pneumonia: —

Counties of Massachusetts arranged according to their Death Rates from Pneumonia (1871-90), that of the State being 100, the Density of Population expressed in Acres to Each Person.

COUNTIES.	Density of Population. Acres per Inhabitant (Census of 1880).	Mortality Rank from Pneumonia, the State = 100.
Nantucket,	11.2	61
Dukes,	18.4	68
Barnstable,	7.5	73
Plymouth,	5.9	74
Norfolk,	3.3	83
Bristol,	2.7	90
Essex,	1.3	93
Middlesex,	1.7	98.5
Worcester,	4.4	98.6
THE STATE,	2.9	100
Hampshire,	7.7	100.3
Hampden,	3.9	103.1
Franklin,	11.8	103.8
Berkshire,	8.9	105
Suffolk,	.07	120

In the following table the counties are arranged in three groups, in the order of their density of population: —

Counties grouped according to their Density of Population.	COUNTIES.	Acres to Each Person.		Mortality Rank from Pneumonia.	
I. County in which there is less than one acre to each person,	Suffolk,	.07		120	
II. Counties having more than one but less than four acres to each person,	Essex,	1.3	Average, 2.1.	93	Average, 95.
	Middlesex,	1.7		99	
	Bristol,	2.5		90	
	Norfolk,	3.3		83	
	Hampden,	3.9		103	
III. Counties having more than four acres to each person,	Worcester,	4.4	Average, 6.4.	99	Average, 94.
	Plymouth,	5.9		74	
	Hampshire,	7.7		100.3	
	Berkshire,	8.9		105	
	Barnstable, Dukes and Nantucket,	9.0		72	
	Franklin,	11.8		103.8	

By this grouping the mortality may be conveniently stated as follows: —

Mortality of *dense* districts, ...	1,000
Mortality of *medium* districts, ...	792
Mortality of *sparse* districts, ...	783

Classification by Towns.

The classified list of cities and towns shows the following points relative to the geographical distribution of pneumonia. In one town only (Gosnold) there were no deaths reported from this cause during the twenty years in question, and this was the smallest town in population in the State.

Out of the 10 towns having extremely low ratios (more than fifty per cent. below that of the State), including Gosnold, 5 are sea-coast towns (Gosnold, Brewster, Harwich, Hull and Marion). Three of the remainder, Burlington, Dracut and Weston, are within twenty miles of the sea, while Hawley and Goshen are inland towns in Franklin and Hampshire counties.

Out of the 56 towns and cities which lie upon the sea-coast, including Boston, 6 only had high or extremely high ratios of mortality from pneumonia, and these were Rowley, Essex, Marblehead, Salem, Boston and Mashpee.

Still further, out of the 68 cities and towns composing the five south-eastern counties of Bristol, Barnstable, Plymouth, Dukes and Nantucket, only three, Halifax, Rochester and Mashpee, had high or extremely high ratios, and the Indian town of Mashpee stood at the extreme of high ratios in this group.

On examining the extreme of high ratios, we find that, out of 20 towns having extremely high ratios, 15 are in the five western and central counties, and 7 of these towns are west of the Connecticut River.

Out of the 162 cities and towns which comprise the five western and central counties of Berkshire, Franklin, Hampshire, Hampden and Worcester, 81, or one-half, are to be found among those which had a mortality rate from pneumonia higher than that of the State. But the population of these cities and towns was only 44 per cent. of the total population of these counties.

Elevation Above Sea Level. — The majority of the people living in towns in the five western and central counties having high pneumonia death rates live at elevations of five hundred feet or more above the sea level. The following are the elevations of such towns and cities having excessive pneumonia death rates, and high elevations, the figures given being the elevations of the villages or inhabited portions of the towns : —

	Feet.
In Berkshire County.	
Peru,	1,700
Dalton,	1,100
North Adams,	800
Monterey,	1,300
Sheffield,	650
In Franklin County.	
Charlemont,	500-600
Heath,	1,650
Colrain,	600
Leyden,	1,000
Conway,	650
Leverett,	500
Shutesbury,	1,100
New Salem,	650-900
In Hampshire County.	
Worthington,	1,500
Westhampton,	700
Pelham,	1,100
Belchertown,	600
Enfield,	500
In Hampden County.	
Holland,	700
In Worcester County.	
Royalston.	1,000
Winchendon,	1,000
Phillipston,	1,150
Lunenburg,	500
Petersham,	1,100
Dana,	500
Hardwick,	900
Sturbridge,	600
Westminster,	1,000
Princeton,	1,150
Sterling,	500
WORCESTER,	500
Charlton,	750
Oxford,	500

On the other hand, some of the principal cities and large towns of this region, situated at low levels, had also low ratios of mortality from pneumonia. Chicopee, Springfield and Northampton, all at elevations of less than one hundred and fifty feet, had low mortality rates from this cause.

Comparing the 20 towns at the two extremes, we find the following results : —

TOWNS.	Elevations.	Mortality Rank.	TOWNS.	Elevations.	Mortality Rank.
Gosnold,	50	0	Sheffield,	650	135
Burlington,	250	35	Heath,	1,650	135
Brewster,	25	41	Shutesbury,	1,100	137
Hawley,	1,750	43	Shirley,	400	139
Harwich,	40	43	Enfield,	600	139
Weston,	150	44	Greenwich,	450	140
Hull,	25	46	Royalston,	1,000	143
Marion,	20	46	Sturbridge,	600	144
Goshen,	1,450	48	West Stockbridge,	900	146
Dracut,	150	49	Rowley,	50	147
Nahant,	25	51	New Salem,	800	150
Washington,	1,500	51	Monterey,	1,300	150
Blackstone,	200	52	Westhampton,	700	151
Boxford,	100	54	Charlemont,	550	152
Tewksbury,	100	54	Harvard,	400	154
Southborough,	300	55	North Reading,	100	154
Concord,	100	55	Leverett,	700	157
Saugus,	50	56	Carlisle,	200	158
Stoneham,	100	57	Lanesborough,	1,200	172
Wellfleet,	30	57	Mashpee,	50	201

The average elevation of the first 20 towns above sea level is 320 feet, and their average distance from the sea 25 miles. The average elevation of the last 20 towns is 670 feet, and their average distance from the sea 70 miles.

The eight towns having elevations of 1,000 feet or more have very small populations, and hence have an undue effect upon the estimate. If these are omitted in this enumeration, the relative differences of these two groups of towns become much more apparent.

The average elevation of the former group, omitting the small towns of high elevation, is 100 feet, and the average distance from the sea 11 miles. The average elevation of the latter group is 475 feet, and the average distance from the sea 60 miles.

A few hill-top towns, in which the principal villages were upon high hills in exposed locations, had low mortality rates from pneumonia; as Spencer, which ranked 84; Leicester, also 84; and Westford, 88.

There appears to have been a tendency to pneumonia in certain localities. Nearly all the elevated towns along the northern border of the State, from Winchendon, sixty miles

westward, to North Adams, had high mortality ratios from pneumonia. Another group extends from Peru south-eastward along the north bank of the Westfield River to West Springfield. Another larger group, including 15 towns, extends from Conway eastward across the Connecticut River as far as Phillipston and southward to Belchertown. Another group begins upon the easterly slope of Mt. Wachusett, and extends eastward to Stow, including 9 towns. Four more are grouped along the southern border of Worcester and Hampden counties. Another group extends eastward in Essex County, following nearly the basin of the Ipswich River to the sea.

The following table gives the comparative mortality rank of the cities from this cause: —

Newton,	63	Haverhill,	94
Brockton,	67	Chicopee,	95
Malden,	71	Northampton,	95
Gloucester,	74	Fall River,	96
Marlborough,	79	Springfield,	98
Pittsfield,	79	Chelsea,	103
Taunton,	82	Lowell,	105
New Bedford,	84	Salem,	108
Fitchburg,	84	Holyoke,	110
Woburn,	85	Somerville,	112
Waltham,	85	Worcester,	112
Quincy,	89	Cambridge,	116
Lynn,	90	Lawrence,	117
Newburyport,	91	Boston,	124

Pneumonia.

Town in which there were no deaths from pneumonia in the twenty years: Gosnold.

Towns in which the mortality rate from pneumonia was more than fifty per cent. below the average of the State: —

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Burlington,	8	35	Hull,	7	46
Brewster,	15	41	Marion,	14	46
Hawley,	8	43	Goshen,	5	48
Harwich,	44	43	Dracut,	25	49
Weston,	20	44			

Pneumonia — Continued.

Cities and towns in which the mortality rate from pneumonia was below that of the State but not fifty per cent. below it:—

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Nahant,	13	51	Swampscott,	53	67
Washington,	8	51	Mattapoisett,	29	67
Blackstone,	81	52	Winchester,	81	67
Boxford,	14	54	Bedford,	20	68
Tewksbury,	37	54	Fairhaven,	62	68
Southborough,	37	55	Middleborough,	113	68
Concord,	69	55	Orleans,	28	68
Saugus,	50	56	Truro,	22	68
Stoneham,	88	57	Ashburnham,	45	69
Wellfleet,	34	57	Acushnet,	24	69
Kingston,	28	58	Chatham,	49	69
Westborough,	96	58	Plainfield,	10	69
Hopkinton,	85	58	Norwood,	56	69
Sherborn,	26	59	Paxton,	13	69
Sandwich,	66	59	West Newbury,	44	70
Plympton,	13	59	Millbury,	105	70
Andover,	97	59	Melrose,	118	70
Boxborough,	6	59	Belmont,	36	70
Dartmouth,	65	60	Franklin,	91	71
North Andover,	61	60	Hudson,	84	71
Salisbury,	78	60	Groveland,	50	71
Newbury,	30	60	Billerica,	45	71
Whitman,	52	61	MALDEN,	314	71
Holbrook,	39	61	Berkley,	21	72
Nantucket,	72	61	Palmer,	125	72
Mt. Washington,	4	62	Lakeville,	23	72
New Ashford,	4	62	Walpole,	57	72
Auburn,	26	62	Reading,	73	72
Medway,	78	62	Easton,	118	72
North Brookfield,	88	62	Plymouth,	164	73
Scituate,	49	63	Littleton,	23	73
NEWTON,	360	63	Lexington,	61	73
Middlefield,	13	63	Dudley,	65	73
Chilmark,	10	64	Gardner,	129	73
Canton,	92	64	Rockport,	91	73
Tisbury,	31	64	Medfield,	32	74
Gill,	15	65	Hancock,	15	74
Hanover,	39	65	Somerset,	47	74
Brookline,	176	65	Dedham,	146	74
Pembroke,	29	65	GLOUCESTER,	459	74
Monson,	78	66	Westport,	68	74
Rockland,	82	66	Everett,	127	74
Adams,	211	66	Beverly,	200	75
Merrimac,	34	66	Duxbury,	52	75
Hingham,	94	66	Uxbridge,	74	75
BROCKTON,	339	67	Lenox,	52	75
Carver,	22	67	Revere,	69	76

Pneumonia — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Framingham, ...	163	76	Tolland, ...	12	84
Wareham, ...	70	76	FITCHBURG, . . .	390	84
Bradford, ...	67	76	Agawam, . . .	59	84
Bridgewater, . . .	88	77	Maynard, . . .	61	84
Manchester, . . .	40	77	Leicester, . . .	74	84
Cottage City, . . .	11	77	Hanson, ...	35	84
Holden, ...	61	77	Dennis, ...	88	84
Wellesley, . . .	87	78	Amherst, . . .	115	84
Marshfield, . . .	44	78	Hatfield, ...	40	84
Cohasset, ...	54	78	Seekonk, . . .	33	85
Webster, ...	141	78	Norfolk, ...	25	85
Gay Head, . . .	4	78	Greenfield, . . .	114	85
Granville, . . .	30	79	WOBURN, ...	293	85
MARLBOROUGH, . .	260	79	WALTHAM, . . .	347	85
West Boylston, . .	75	79	New Marlborough, .	51	86
Pittsfield, ...	343	79	Wakefield, . . .	153	86
Dighton, ...	45	79	Warren, ...	106	86
Holliston, ...	78	79	Provincetown, . .	119	86
Falmouth, . . .	61	79	Norwell, ...	50	87
Savoy, ...	18	79	Milford, ...	256	87
Weymouth, . . .	267	80	Edgartown, . . .	38	88
Ashfield, ...	27	80	Mansfield, . . .	79	88
Lincoln, ...	23	80	Chelmsford, . . .	71	88
Winthrop, . . .	32	80	Georgetown, . . .	62	88
Hyde Park, . . .	184	80	Wrentham, . . .	69	88
Williamsburg, . . .	57	80	Abington, . . .	103	88
Medford, ...	204	80	Granby, ...	21	88
Wayland, ...	50	80	Attleborough, . .	310	88
Freetown, . . .	34	81	Westford, . . .	60	88
Acton, ...	46	81	Wendell, . . .	13	88
Needham, ...	98	81	QUINCY, ...	316	89
Watertown, . . .	145	81	Shelburne, . . .	46	90
Yarmouth, . . .	56	81	Cummington, . .	25	90
West Bridgewater, . .	43	82	Williamstown, . .	106	90
Tyringham, . . .	14	82	LYNN, ...	1,148	90
Milton, ...	85	82	Danvers, ...	189	90
Eastham, ...	18	82	Peabody, . . .	253	90
Stoughton, . . .	127	82	Dunstable, . . .	13	91
TAUNTON, . . .	571	82	Alford, ...	10	91
Prescott, ...	12	82	NEWBURYPORT, . .	389	91
Raynham, . . .	44	83	Oakham, ...	25	91
Orange, ...	83	83	Grafton, ...	116	91
East Bridgewater, . .	71	83	Foxborough, . . .	85	91
Amesbury, . . .	135	83	Methuen, . . .	127	91
Sudbury, ...	81	83	Leominster, . . .	159	92
NEW BEDFORD, . .	784	84	Douglas, ...	65	92
Spencer, ...	198	84	Brookfield, . . .	82	92
Swanzey, ...	36	84	Sutton, ...	91	92
Templeton, . . .	74	84	Easthampton, . .	124	93

Pneumonia — Continued.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Ashby,	27	93	Clarksburg,	22	96
Monroe,	6	93	Norton,	53	97
Rehoboth,	56	93	Dover,	20	97
Natick,	252	94	Berlin,	30	97
Sandisfield,	33	94	Ipswich,	114	97
Erving,	26	94	Clinton,	244	97
HAVERHILL,	571	94	Egremont,	27	97
Barnstable,	127	95	Warwick,	22	97
CHICOPEE,	338	95	SPRINGFIELD,	1,072	98
Hamilton,	28	95	Hubbardston,	43	98
Southbridge,	194	95	Chesterfield,	24	98
NORTHAMPTON,	370	95	Ware,	166	98
Upton,	61	95	Montague,	141	99
West Brookfield,	58	96	Ludlow,	48	99
Boylston,	26	96	Sharon,	47	99
FALL RIVER,	1,536	96	THE STATE,	56,474	100

Cities and towns in which the mortality rate from pneumonia was above that of the State but not fifty per cent. above it: —

Longmeadow,	51	100	SALEM,	931	108
Tyngsborough,	20	100	Pepperell,	81	108
Blandford,	31	100	New Braintree,	21	109
Princeton,	35	100	Sunderland,	26	109
Otis,	25	100	Hampden,	20	110
Chester,	47	101	Braintree,	145	110
Townsend,	63	101	Northbridge,	141	110
Richmond,	36	101	Wenham,	31	110
Lynnfield,	22	101	Wilbraham,	57	110
Wales,	33	101	HOLYOKE,	789	110
Wilmington,	30	101	Great Barrington,	163	111
Northfield,	52	102	Buckland,	61	111
South Hadley,	115	103	Hadley,	68	111
CHELSEA,	746	103	Northborough,	59	111
Athol,	150	103	Florida,	26	111
Windsor,	21	103	Russell,	29	111
Bellingham,	40	103	Essex,	59	111
Mendon,	36	104	Hardwick,	79	112
Middleton,	38	104	SOMERVILLE,	935	112
Halifax,	18	105	Barre,	86	112
Groton,	62	105	WORCESTER,	2,145	112
LOWELL,	1,927	105	Marblehead,	267	113
Ayer,	63	106	Shrewsbury,	54	114
Southwick,	37	106	Topsfield,	42	114
Randolph,	136	107	Westminster,	60	115
Becket,	38	107	Holland,	11	115
Deerfield,	120	107	Cheshire,	56	115
Brimfield,	41	108	CAMBRIDGE,	1,984	116
Conway,	60	108	Rutland,	39	116

Pneumonia — Concluded.

	Number of Deaths.	Mortality Rank.		Number of Deaths.	Mortality Rank.
Stockbridge, . . .	87	116	Rowe, ...	20	126
Worthington, . . .	28	117	Bolton, ...	36	126
LAWRENCE, . . .	1,381	117	Whately, . . .	43	126
Westfield, . . .	306	117	Phillipston, . . .	25	127
Colrain, ...	66	117	Petersham, . . .	45	128
Southampton, . . .	39	118	Bernardston, . . .	38	128
North Adams, . . .	314	118	Lancaster, . . .	82	129
Pelham, ...	23	118	Winchendon, . . .	153	130
Ashland, ...	90	119	Leyden, ...	21	131
Charlton, ...	72	120	Belchertown, . . .	98	132
Oxford, ...	99	120	Sterling, ...	60	134
Huntington, . . .	47	120	Lunenburg, . . .	41	134
Arlington, . . .	156	120	Sheffield, . . .	94	135
Lee, ...	150	120	Heath, ...	24	135
Stow, ...	40	121	Shutesbury, . . .	23	137
Rochester, . . .	40	121	Shirley, ...	60	139
West Springfield, . .	160	122	Enfield, ...	46	139
Hinsdale, ...	62	123	Greenwich, . . .	28	140
Dalton, ...	80	123	Royalston, . . .	54	143
Dana, ...	29	124	Sturbridge, . . .	94	144
BOSTON, ...	14,120	124	Carlisle, ...	24	146
Montgomery, . . .	12	125	West Stockbridge, .	89	146
Peru, ...	16	125	Rowley, ...	56	147

Towns in which the mortality rate from pneumonia was more than fifty per cent. above that of the State: —

New Salem, . . .	41	150	North Reading, . .	44	154
Monterey, . . .	30	150	Leverett, ...	37	157
Westhampton, . . .	27	151	Lanesborough, . .	70	172
Charlemont, . . .	45	152	Mashpee, . . .	22	201
Harvard, ...	61	154			

CONCLUSIONS.

The foregoing report is intended as a statistical study of the general subject of the geographical distribution of diseases in Massachusetts, with the hope that the facts therein presented may prove valuable in the prevention of such diseases as are acknowledged to be preventable.

To a certain extent it may serve the purpose of determining what cities and towns are healthful as places for residence, but such is not the primary intent of the writer. The question, what constitutes a healthful town, depends not upon any single condition, but upon a great many conditions and circumstances.

It is not an easy matter to determine the relative effect of

such conditions and circumstances as influencing the death rate of cities and towns. They may be grouped in three general classes as follows: —

1. *Natural Conditions.* — Such as the conditions of climate (temperature, rainfall, humidity, prevailing winds), elevation above sea level, distance from sea, character of the soil (dryness or moisture).

2. *Artificial Conditions.* — Density of the population, purity of water supply, efficiency of sewerage system and sewage disposal, sufficiency and purity of food supply, and especially of milk, protection from accidents, management and prevention of infectious diseases, freedom of intercommunication, especially among children, efficiency of municipal sanitation.

3. *Character of the Population.* — Race and nationality, distribution by sexes and ages, occupation, education, social condition as to poverty or wealth, habits, size of families, etc.

Each of the foregoing conditions probably influences the length of human life in a greater or less degree.

In estimating the death rate of cities and towns presented in the first part of this paper, a distinction is maintained between death rate as calculated from the actual number of deaths registered in a given city or town for a definite period, and the true death rate of the resident or census population. For this reason, in estimating the death rates of cities and towns allowance has been made, where actual numbers were known, for the following circumstances: —

Deaths of non-resident invalids at summer resorts. Deaths by shipwreck upon the coast and at sea, and by drowning at beaches (of non-residents). For example, there were 2,103 such deaths of Gloucester fishermen, and 37 at Hull and 10 at Nantucket, during the twenty-year period. There were also 229 deaths of non-residents, mostly invalids, at Cottage City, Hull and Nantucket in the same time. Deaths of non-residents at public institutions. If it were possible to obtain the exact numbers, it would be proper to reduce the death rate of the larger cities and especially of Boston in consequence of two causes: 1. The deaths of non-residents in hospitals, asylums and charitable institutions, who have sought the cities for treatment. 2. The daily accession of a multitude of people from suburban districts, who are not included in the census of the

cities, but contribute to a certain extent to the death rate. (The ratio of fatal accidents reported in Suffolk County in 1890, as compared with the resident population of that census year, was 5.8 per 10,000, while that of the State at large was only 3.8 per 10,000.)

The fallacy of drawing conclusions from small numbers of people and from short periods of time must be acknowledged as a statistical axiom; and hence the general conclusions of this paper have been drawn, as far as possible, from groupings of towns and cities extending over a period of twenty years.

MEASLES. — In the section upon *measles*, the inquiry shows that the course of the disease was very variable from year to year, the mortality rate of 1872 from this cause being nearly thirty times as great as that of the minimum year of mortality from the same cause (1879).

Density of population appears to have furnished a favorable condition for its spread.

Geographical position does not appear to have had a marked influence upon the mortality rate from this disease, except in so far as towns were near to or remote from large and densely settled centres of population, and in free communication with them.

SCARLET-FEVER. — This disease prevailed during the period with greater regularity and with a greater mortality rate than measles. The extreme of its high mortality (in 1875) was about twelvefold greater than that of the minimum year (1889).

Density of population appears to have favored its spread. As in the case of measles, the mortality rate from this cause was least in small, sparsely settled towns, with poor facilities for intercommunication with large cities.

The difference in mortality rate from this cause of the two large manufacturing cities (Lowell and Fall River), with similar populations, is worthy of note, Lowell being below the average of the State and Fall River far above it.

Geographical position does not appear to exert a marked influence on the prevalence of this disease.

DIPHTHERIA AND CROUP. — The extremes of mortality in different years have not been so great as in the case of measles and scarlet-fever; that of the highest year (1876) was 19.9 per 10,000, and that of the lowest (1873) was 4.7.

Density of population appears to have afforded a favorable condition for its spread.

Geographical distribution does not appear to have been a prominent factor, except in the fact that a small north-west portion of the State, which is all at a high elevation above the sea, appears to have suffered most severely.

SMALL-POX. — During all of the years of the period under consideration, except the first three, the State was comparatively exempt from this scourge. The extremes of mortality were 0 in 1886 and 6.7 per 10,000 in 1872.

The conditions which appear to have influenced the mortality from small-pox in Massachusetts are: density of population, nearness to or remoteness from large centres of population, the use of rags in the manufacture of paper, and the thoroughness with which vaccination and revaccination have been performed. Aside from these conditions, geographical position does not appear to have had material effect upon its prevalence.

As a common factor favorable to the spread of each one of the foregoing diseases (measles, scarlet-fever, diphtheria and small-pox), independent of density of population, location upon one of the principal railway lines of communication appears to have had a marked influence.

TYPHOID FEVER. — The mortality from typhoid fever was less variable in its fluctuations than that of either of the diseases before mentioned, the extremes being 3.7 per 10,000 in 1879 and 1890, and 11.1 in 1872. In general, there was a decided decrease, comparing the two decades, from 6.2 in the former to 4.5 in the latter.

Density either does not appear to have had a controlling influence upon the mortality from typhoid fever, or its effect is counterbalanced by the presence of good public water supplies. In cities having a comparatively dense population and a generally polluted water supply, the mortality rate was high.

The greater number of towns lying in certain river valleys had unusually high ratios of typhoid mortality. This applies to the Connecticut and the Chicopee. In the case of the former river it has no apparent relation to the public water supply in the majority of the towns lying within ten miles of its eastern bank, since most of these towns have no public water supply. In the case of the lower portion of the Chicopee, every town

had a high mortality from this cause, beginning with Ware, which had the highest of any town in the State except Dalton; and further down the stream, Palmer, Belchertown, Ludlow, Wilbraham, Monson, Chicopee and Springfield, all had unusually high typhoid mortality. The high mortality of the two principal cities in the lower Merrimack valley has already been made the subject of a paper by H. F. Mills, C.E., in the last annual report of the Board, in which it was shown that a polluted water supply was the undoubted cause of the excessively high mortality rate. The greater part of Essex County, lying south of the Merrimack River, was unusually free from the disease, and so also was the entire suburban metropolitan district adjoining Boston.

Cholera Infantum. — The extremes of mortality from this cause were 21.7 per 10,000 in 1872, and 7.9 per 10,000 in 1879.

Density of population has a marked effect in increasing the mortality from this disease.

The quality of the milk supply appears to have a definite relation to the mortality from cholera infantum.

The employment of married women in industrial operations away from their homes also co-exists with high mortality from cholera infantum.

Consumption. — Consumption has presented a more uniform mortality rate from year to year than any other disease; the extremes were 36.2 per 10,000 in 1872, and 25.7 in 1889. The average for the twenty years was 30.8. There was a gradual decrease from the beginning to the end of the period, the first decade having a mortality rate of 32.7, and the second of 29 2.

The extremes of mortality were in Berkshire and Franklin, which had low death rates from this cause; and Nantucket and Suffolk, which had high rates.

Density appears to have affected the mortality rate from consumption, in the ratio of 1,000 deaths for dense, 810 for medium and 727 for sparse districts.

Geographical position also exercises a marked controlling effect in proportion to the distance of the districts from the sea-coast, the mortality rate decreasing from the sea-coast counties toward Berkshire, at the western extremity of the State. The altitude of the region also generally increases westward or inland.

PNEUMONIA. — The mortality rate from pneumonia was also comparatively uniform during the twenty-year period, the extremes being 12.4 per 10,000 in 1871, and 18.2 in 1888. There was an increase from 14.6 per 10,000 in the first ten years to 16.6 in the second ten years.

The effect of density upon the mortality from this disease does not appear to have been so decided as in the case of other well-known infectious diseases, the ratio being as 15.6 per 10,000 for the densely settled towns, and 14.1 for the sparsely settled.

Geographical position, with reference to distance from the sea-coast, appears to have had a marked coincidence with the mortality rate, the inland counties presenting a high mortality rate and the sea-coast counties a low one. Elevation above the sea also appears to have coincided with a high mortality from this cause. With reference to these two conditions, distance from the sea-coast and elevation above sea level, consumption and pneumonia appear to be to a considerable degree complementary.

In connection with the foregoing summary the following condensed statistics are presented, which have reference to the relation of sex, age and season of the year to the diseases under consideration. They will be found useful in making a more complete study of the subject.

In the table which relates to the mortality by months (page 873) the percentages have been reduced to uniform periods of one-twelfth of a year, in order the better to show the actual incidence of the disease at each such period.

* In a very small number of cases the sex was unknown. The numbers were quite small, and are therefore disregarded in the foregoing tables.

The following figures give the mortality by sex, the deaths of each sex from the given disease being compared with the persons living of each sex, and in the case of diseases peculiar to children the comparison is made with the persons living of each sex of ages from 0 to 10, and in the case of cholera infantum from 0 to 5.

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* In the first table on the following page the only diseases in which the difference in the mortality of the sexes is excessive and worthy of special notice are small-pox and phthisis. For every 1,000 males who died of small-pox there were 662 deaths of females. It is worthy of note, however, that the mortality of the sexes at different ages presented a wide variation. While the mortality of the two sexes for the period of life 0-20 years was exactly equal, or 50 per cent. of each, that of the remainder of life was 70.5 per cent. for males and 29.5 per cent. for females. It would appear that this remarkable result is due to the much greater exposure of males to infection in adult life, while that of children is practically equal; and not even the fact of a greater exposure of female operatives in the paper-making industry is sufficient to counterbalance the still greater exposure of males in other densely settled communities.

Ratio of Deaths by Sex, Massachusetts (1871–90)

		Measles.	Scarlet-fever.	Diphtheria and Croup	Small-pox.	Typhoid Fever.	Cholera Infantum.	Phthisis.	Pneumonia.
Percentage of each sex,	Male,	49.5	49.3	49.9	60.2	52.4	53.3	45.4	50.7
	Female,	50.5	50.7	50.1	39.8	47.6	46.7	54.6	49.3
Total,		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
In absolute numbers, the males being 1,000,	Male,	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
	Female,	1,021	1,030	1,005	662	907	876	1,202	974
Compared with the number living of each sex at all ages,	Male,	-	-	-	1,000	1,000	-	1,000	1,000
	Female,	-	-	-	614	841	-	1,115	904
Compared with the number living of each sex under 10 years of age,	Male,	1,000	1,000	1,000	-	-	-	-	-
	Female,	1,034	1,044	1,019	-	-	-	-	-
Compared with the number living of each sex under 5 years of age,	Male,	-	-	-	-	-	1,000	-	-
	Female,	-	-	-	-	-	892	-	-

Death Rates per 10,000 of the Population living at Each Age Period of Life

	Measles.	Scarlet-fever.	Diphtheria and Croup.	Small-pox.	Typhoid Fever.	Cholera Infantum.	Consumption.	Pneumonia.
Under 5 years,	9.94	32.97	64.73	2.34	4.84	114.59	17.25	48.02
5 to 10 years,	1.10	12.66	24.56	.52	3.93	-	3.23	4.30
10 to 15 years,	.23	2.69	5.71	.26	5.13	-	6.49	1.81
15 to 20 years,	.25	.93	1.72	.65	9.90	-	31.75	3.85
20 to 30 years,	.19	.41	.83	1.02	8.89	-	50.25	5.24
30 to 40 years,	.09	.16	.60	.51	5.27	-	43.83	7.78
40 to 50 years,	.09	.05	.39	.28	4.41	-	36.74	11.56
50 to 60 years,	.07	.06	.37	.28	5.07	-	36.51	18.62
60 to 70 years,	.09	.05	.53	.26	7.64	-	48.00	36.47
70 to 80 years,	.23	.04	.56	.29	12.15	-	60.22	75.16
Over 80,	.24	.03	.46	.55	14.32	-	44.48	133.63

The mortality for phthisis was in the ratio of 1,000 males to 1,202 females, or, when compared with the number living of each sex, as 1,000 males to 1,115 females. The mortality of the sexes also differed considerably at different ages, that of females being greatest for all ages up to 30 years, while that of males was greatest for all the later ages from 30 to 80 years.

In the table of age periods the most noteworthy departure from what may be termed a normal rate of increase or decrease from one age period to another exists in the column for small-pox. In the few instances of such tables as have been preserved in Europe from the statistics of the pre-vaccination period, the death rate from small-pox of children under 5 years was very much greater than that of the present day, while that of the later ages was comparatively small. In the present table for Massachusetts the large ratio of deaths of children under 5 years corresponds to the experience of partially vaccinated populations, and the increasing ratio at the ages 10–30 undoubtedly indicates a neglect of re-vaccination at a time when the renewed susceptibility to small-pox has not been met by re-vaccination of persons living at those ages.

Seasonal Mortality.

[See diagram on the following page.]

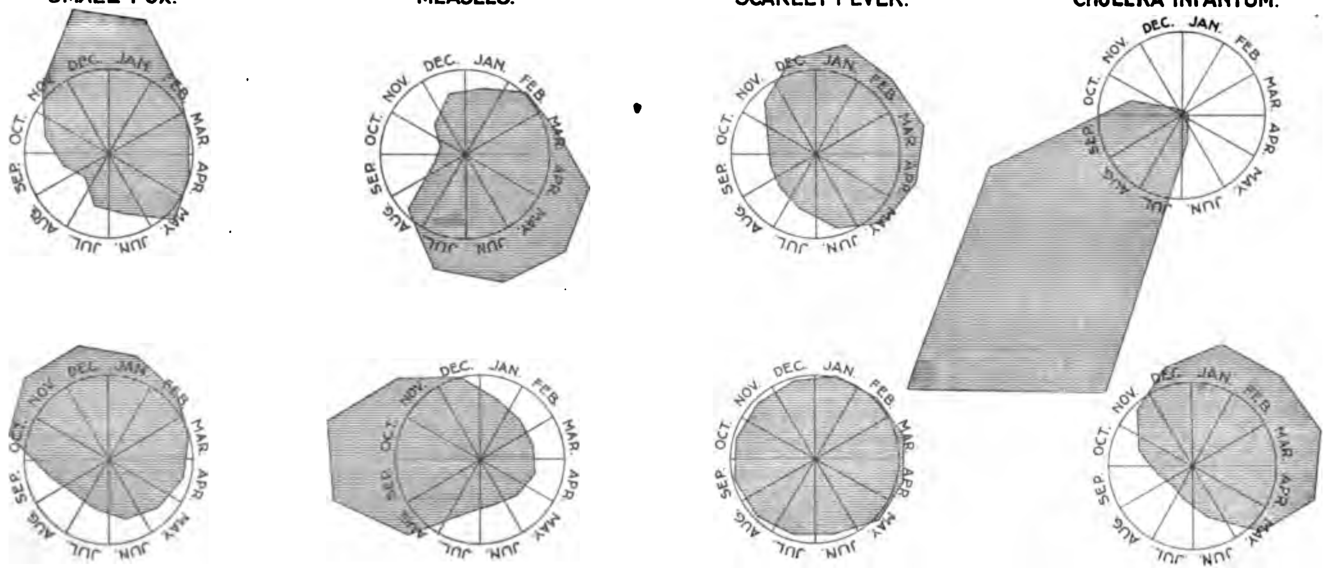
Percentages of Deaths in Different Months of the Year (1871-90).

	Measles.	Scarlet-fever.	Diphtheria and Croup.	Small-pox.	Typhoid Fever.	Cholera Infantum.	Consumption.	Pneumonia.
January,	6.82	11.35	10.85	13.93	6.39	.44	8.52	12.64
February,	8.69	10.68	9.50	9.62	5.66	.41	8.65	12.86
March,	9.48	11.07	8.23	8.23	5.62	.49	9.04	13.44
April,	12.84	10.46	7.64	8.33	5.63	.55	9.02	12.63
May,	13.99	9.68	6.90	9.23	5.00	.76	8.74	9.50
June,	13.17	7.71	6.12	6.23	4.72	2.69	7.78	5.30
July,	11.91	5.70	5.01	5.43	5.62	28.87	7.79	3.50
August,	6.95	4.77	4.92	3.38	10.47	38.85	8.10	2.90
September,	3.14	4.57	7.01	4.69	15.14	19.98	8.24	3.68
October,	2.59	6.07	10.36	6.52	15.64	5.86	8.03	5.51
November,	4.23	8.37	11.72	9.53	11.60	1.11	7.99	7.91
December,	6.19	9.57	11.74	14.87	8.41	.49	8.09	10.15

The following table affords a good illustration of the truth of Dr. Farr's rule or statement, relative to the effect of density of population in increasing the death rate from infectious diseases. In the direction westward toward Berkshire County the same uniformity is not shown, since the diminishing ratio of density is not maintained in that direction, Hampden having a greater density than Worcester County. In the southward direction, however, as shown in the following table, the mortality rate from two of the principal infectious diseases decreases inversely with the distance from the metropolitan county of Suffolk and the density of population (expressed in acres per inhabitant): —

COUNTIES.	Measles.		Scarlet-fever.		Density of Population. Acres per Inhabitant.	Average Distance from Metropolitan County. Miles.
	Death Rate per 10,000.	Numerical Rank, the State = 100.	Death Rate per 10,000.	Numerical Rank, the State = 100.		
Suffolk,	1.82	164	4.98	121	.07	0
Norfolk,	.44	40	3.78	92	3.5	10
Plymouth,	.42	38	2.68	65	5.9	25
Barnstable,	.34	31	1.83	45	8.4	70
Dukes,	.23	21	1.28	31	18.4	80
Nantucket,	.13	12	.67	16	9.1	100

MASSACHUSETTS.



The diagrams shown above are intended to illustrate the seasonal mortality from the eight causes of death presented on page 873.

In the construction of these diagrams, the radius of the circle represents the average mortality of one month. The actual mortality of each month is represented relatively by the distance of the points or angles of the shaded areas from the centre of the circle. The shaded areas do not express the actual mortality quantitatively.

The total numbers of deaths from which the diagrams are constructed are stated on page 769.

HEALTH OF TOWNS.

HEALTH OF TOWNS.

Under this title are presented abstracts of such reports of the local boards of health as have been received at the office of the State Board. A general review of these reports shows that a constantly increasing interest in all matters pertaining to public hygiene is manifest throughout the State. The public health would undoubtedly be promoted very much if the harmonious relations which already exist between the State and local boards were made more effective by the requirement that all local boards, or at least those of the cities and large towns, should send copies of their annual reports to the State Board of Health as well as to their own citizens.

Among the sanitary matters which appear to have been foremost was the increased attention paid to public water supplies and sewerage systems. The experimental and advisory work of the Board upon these important questions occupies the principal part of this volume.

The question of the disposal of garbage, street sweepings and house refuse has attracted more than usual interest, and several of the larger cities are considering the question, with the intention of erecting establishments for such disposal. There is great need of some better methods than those largely practised in the State. None of the older modes of disposal are entirely satisfactory. The dumping of garbage in enormous heaps, to putrefy and cause a constant nuisance; the feeding of decomposed material to cattle and swine; the depositing at sea, where it occasionally floats upon the shore of some crowded summer resort, — all of these modes have objections of greater or less weight, according to the degree of injury thus created. Hence more perfect systems of disposal are demanded, like those in use in British cities and in some municipalities of our own country.

Another question which has been prominent in the cities is the need of separate hospitals in which persons becoming sick with infectious diseases can be isolated.

By the provisions of two statutes, which have existed for many years, it is incumbent, both upon the householder and the attending physician, to report each case of disease dangerous to the public health to the selectmen or local board of health. The statute relative to the householder was enacted in 1792, a century ago, and that relating to the physician in 1827. Originally the only specified disease to which this statute applied was small-pox. The statute was amended in 1884 by specifying also diphtheria and scarlet-fever. Other amendments required the disinfection of infected houses, and still further the keeping of records of cases which have been duly notified to the local boards of health. These record books of infectious diseases have proved very valuable for the purpose of tracing the course and origin of epidemics in towns and cities, and each succeeding year finds a better compliance with the laws relating to the recording of reported cases of infectious disease. It would be an improvement if the statute required the notices of the more dangerous infectious diseases to be sent to the State Board of Health as well as to the local board.

From the annual reports of the local boards of health for 1891 the following table has been compiled, in which are presented the total number of cases of infectious disease which have been reported to the local boards of health, so far as they are published in the reports sent to the office of the State Board of Health, together with the number of deaths from the same causes.

From this table it appears that the number of reported cases and deaths a[illegible] percentages of deaths to reported cases was as follows:

Reported cases o[illegible]	2,444
[illegible]rted deaths fr[illegible]	575
[illegible]centage of d[illegible]	23.5
[illegible] of scarlet-[illegible]	4,517
[illegible] from scarle[illegible]	151
[illegible] to re[illegible]	3.34

Reported cases of typhoid fever, ... 2,414
Reported deaths from typhoid fever, ... 460
Percentage of deaths to reported cases, ... 19.05

Reported cases of measles, ... 5,861
Reported deaths from measles, ... 84
Percentage of deaths to reported cases, ... 1.4

The foregoing percentages may be considered as somewhat larger than the actual percentages of fatalities from these diseases during the year, for the reason that the number of deaths is known, while the number of reported cases is probably somewhat less than the actual number.

The two diseases, scarlet-fever and measles, undoubtedly prevailed in an unusually benign form, since the percentage of fatality from these diseases (3.3 and 1.4) is considerably less than the average fatality in a long period of years.

Certain Infectious Diseases reported to Local Boards of Health.

	Diphtheria.		Scarlet-Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Amesbury,	27	-	5	-	19	-	20	-
Attleborough,	53	17	8	-	28	4	-	-
Ayer,	10	-	3	-	7	-	210	2
Belmont,	3	1	2	-	2	-	4	-
Beverly,	1	1	81	1	-	-	-	-
Blackstone,	13	-	4	-	-	-	-	-
Boston,	831	232	1,327	64	966	154	2,588	21
Bradford,	3	-	4	-	-	-	6	-
Bridgewater,	2	-	2	-	7	3	-	-
Brookline,	7	-	39	1	9	4	-	-
Cambridge,	115	15	354	10	70	16	-	8
Canton,	4[1]	-	15	-	3	-	-	-
Chelsea,	72	15	116	5	26	9	-	-
Chicopee,	9	-	42	1	Many.	-	-	-
Clinton,	12	-	116	-	14	-	-	-
Easthampton,	13	6	1	-	-	-	-	-
Everett,	30	5	50	2	30	4	125	2
Fall River,	35	10	49	5	245	45	-	-
Fitchburg,	21[1]	7	53	-	13	5	316	4
Franklin,	5	2	9	-	-	-	-	-
Gardner,	10	1	20	-	-	3	-	-
Gloucester,	34	3	155	1	16	3	-	6
Great Barrington,	0	-	3	-	-	5	-	-
Greenfield,	24	-	8	1	3	-	-	-

[1] Including membranous croup.

Ratio of Deaths by Sex, Massachusetts (1871–90)

		Measles.	Scarlet-fever.	Diphtheria and Croup.	Small-pox.	Typhoid Fever.	Cholera Infantum.	Phthisis.	Pneumonia.
Percentage of each sex,	Male,	49.5	49.3	49.9	60.2	52.4	53.3	45.4	50.7
	Female,	50.5	50.7	50.1	39.8	47.6	46.7	54.6	49.3
Total,		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
In absolute numbers, the males being 1,000,	Male,	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
	Female,	1,021	1,030	1,005	662	907	876	1,202	974
Compared with the number living of each sex at all ages,	Male,	-	-	-	1,000	1,000	-	1,000	1,000
	Female,	-	-	-	614	841	-	1,115	904
Compared with the number living of each sex under 10 years of age,	Male,	1,000	1,000	1,000	-	-	-	-	-
	Female,	1,034	1,044	1,019	-	-	-	-	-
Compared with the number living of each sex under 5 years of age,	Male,	-	-	-	-	-	1,000	-	-
	Female,	-	-	-	-	-	892	-	-

Death Rates per 10,000 of the Population living at Each Age Period of Life

	Measles.	Scarlet-fever.	Diphtheria and Croup.	Small-pox.	Typhoid Fever.	Cholera Infantum.	Consumption.	Pneumonia.
Under 5 years,	9.94	32.97	64.73	2.34	4.84	114.59	17.25	48.02
5 to 10 years,	1.10	12.66	24.56	.52	3.93	-	3.23	4.30
10 to 15 years,	.23	2.69	5.71	.26	5.13	-	6.49	1.81
15 to 20 years,	.25	.93	1.72	.65	9.90	-	31.75	3.85
20 to 30 years,	.19	.41	.83	1.02	8.89	-	50.25	5.24
30 to 40 years,	.09	.16	.60	.51	5.27	-	43.83	7.78
40 to 50 years,	.09	.05	.39	.28	4.41	-	36.74	11.56
50 to 60 years,	.07	.06	.37	.28	5.07	-	36.51	18.62
60 to 70 years,	.09	.05	.53	.26	7.64	-	48.00	36.47
70 to 80 years,	.23	.04	.56	.29	12.15	-	60.22	75.16
Over 80,	.24	.03	.46	.55	14.32	-	44.48	133.63

The mortality for phthisis was in the ratio of 1,000 males to 1,202 females, or, when compared with the number living of each sex, as 1,000 males to 1,115 females. The mortality of the sexes also differed considerably at different ages, that of females being greatest for all ages up to 30 years, while that of males was greatest for all the later ages from 30 to 80 years.

In the table of age periods the most noteworthy departure from what may be termed a normal rate of increase or decrease from one age period to another exists in the column for small-pox. In the few instances of such tables as have been preserved in Europe from the statistics of the pre-vaccination period, the death rate from small-pox of children under 5 years was very much greater than that of the present day, while that of the later ages was comparatively small. In the present table for Massachusetts the large ratio of deaths of children under 5 years corresponds to the experience of partially vaccinated populations, and the increasing ratio at the ages 10–30 undoubtedly indicates a neglect of re-vaccination at a time when the renewed susceptibility to small-pox has not been met by re-vaccination of persons living at those ages.

SEASONAL MORTALITY.

[See diagram on the following page.]

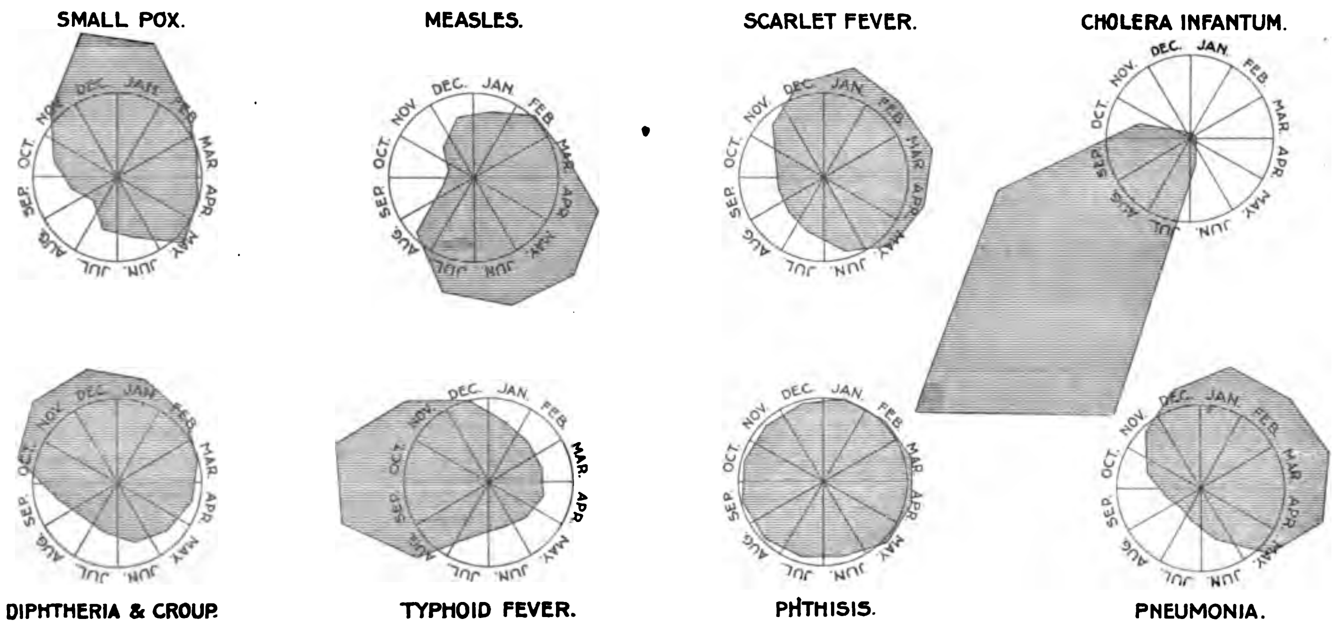
Percentages of Deaths in Different Months of the Year (1871-90).

	Measles.	Scarlet-fever.	Diphtheria and Croup.	Small-pox.	Typhoid Fever.	Cholera Infantum.	Consumption.	Pneumonia.
January,	6.82	11.35	10.85	13.93	6.39	.44	8.52	12.64
February,	8.69	10.68	9.50	9.62	5.66	.41	8.65	12.86
March,	9.48	11.07	8.23	8.23	5.62	.49	9.04	13.44
April,	12.84	10.46	7.64	8.33	5.63	.55	9.02	12.63
May,	13.99	9.68	6.90	9.23	5.00	.76	8.74	9.50
June,	13.17	7.71	6.12	6.23	4.72	2.69	7.78	5.30
July,	11.91	5.70	5.01	5.43	5.62	28.87	7.79	3.50
August,	6.95	4.77	4.92	3.38	10.47	38.85	8.10	2.90
September,	3.14	4.57	7.01	4.69	15.14	19.98	8.24	3.68
October,	2.59	6.07	10.36	6.52	15.64	5.86	8.03	5.51
November,	4.23	8.37	11.72	9.53	11.60	1.11	7.99	7.91
December,	6.19	9.57	11.74	14.87	8.41	.49	8.09	10.15

The following table affords a good illustration of the truth of Dr. Farr's rule or statement, relative to the effect of density of population in increasing the death rate from infectious diseases. In the direction westward toward Berkshire County the same uniformity is not shown, since the diminishing ratio of density is not maintained in that direction, Hampden having a greater density than Worcester County. In the southward direction, however, as shown in the following table, the mortality rate from two of the principal infectious diseases decreases inversely with the distance from the metropolitan county of Suffolk and the density of population (expressed in acres per inhabitant) : —

COUNTIES.	Measles.		Scarlet-fever.		Density of Population. Acres per Inhabitant.	Average Distance from Metropolitan County. Miles.
	Death Rate per 10,000.	Numerical Rank, the State = 100.	Death Rate per 10,000.	Numerical Rank, the State = 100.		
Suffolk,	1.82	164	4.98	121	.07	0
Norfolk,	.44	40	3.78	92	3.5	10
Plymouth,	.42	38	2.68	65	5.9	25
Barnstable,	.34	31	1.83	45	8.4	70
Dukes,	.23	21	1.28	31	18.4	80
Nantucket,	.13	12	.67	16	9.1	100

MASSACHUSETTS.



The diagrams shown above are intended to illustrate the seasonal mortality from the eight causes of death presented on page 873.

In the construction of these diagrams, the radius of the circle represents the average mortality of one month. The actual mortality of each month is represented relatively by the distance of the points or angles of the shaded areas from the centre of the circle. The shaded areas do not express the actual mortality quantitatively.

The total numbers of deaths from which the diagrams are constructed are stated on page 769.

HEALTH OF TOWNS.

contagious diseases. The regulations of the Board prohibit families from sending children to the public schools or frequenting the public library while any member of the household is sick with any contagious disease.

Good judgment will suggest the propriety of exercising care in regard to attending public or private gatherings at such times.

Brookline.

It having come to the knowledge of the Board that the house of one of the milkmen just over the Brighton line, but supplying many Brookline families with milk, was infected with typhoid fever, the necessary steps were at once taken to protect the customers, without much injury to the milkman's business, and with success.

Regulations for the suppression of contagious diseases among domestic animals, prepared by the State Cattle Commissioners, were adopted by the Board, Feb. 19, 1891, entered upon its record, and ordered to be posted throughout the town.

The inspector has visited one hundred and twenty-six dwellings and out-buildings, and eighty-four permits were granted for improving the drainage.

In eleven houses in which there had been scarlet-fever, and in two in which there had been diphtheria, the inspector has disinfected the infected rooms in a thorough manner. In other cases the disinfection was done by the families, and to the satisfaction of the Board.

Cambridge.

Total inspections made in 1891,	6,208
Notices issued,	1,348
Visits and inspections of places where contagious diseases occurred,	1,074
Vaccinations,	415

The Board wishes to express its satisfaction with the results from the addition to its force of a second sanitary inspector, as it was impossible, in a city with the area and population of Cambridge, for one man to discharge in a thorough manner the duties devolving upon such a position. The field covered by preventive medicine has been during the last few years widely extended, and the work done in all branches of sanitary legislation enormously enlarged. When these investigations into the causation of diseases and into the most efficient methods for their prevention now being carried on in this country, Great Britain and on the continent of Europe, are taken into consideration, it is apparent that the man who keeps himself informed on these subjects, in addition to the discharge of his duties as an officer

of a board of health, can have little time to give to outside work, and the combination of the two can hardly allow of each receiving its proper share of attention. We also think that, to insure perfect freedom of action, there should be neither the desires and prejudices of patients nor the relations with fellow-practitioners to be consulted, but that the first and only object for consideration with a health officer should be the public health. We are therefore of the opinion that the time cannot be long postponed when it will be necessary that the executive officer of health, if he is a doctor of medicine, shall cease to be engaged in the practice of his profession.

During the past year the sanitary inspectors have examined the condition of a number of places where cows are kept. In nearly every instance the milk obtained from these cows is sold. These cow stables may, with regard to their condition as to cleanliness, be classed as follows: in forty-eight cases this was found to be good; in eighteen, fair; in twenty-seven, bad. When it is considered that a large part of this milk is consumed by infants and young children, mere cleanliness as estimated by the senses of sight and smell does not necessarily fulfil all the requirements that are needed. When one of these stables is filthy, an order issues from the Board for the abatement of the nuisance, which is followed by a cleaning up of the premises, to be followed, however, in a longer or shorter time, by a relapse into the former condition, and the issue of another order, — a process continuing in a never-ending round. The other undesirable conditions, overcrowding, imperfect ventilation and drainage and improper situation, the Board with its present powers finds it impossible to control. Notification of communicable diseases, unsupplemented by means for their isolation, is a limping measure, and isolation worthy of confidence elsewhere than in a special hospital is in many cases an impossibility.

Considering the unanimity prevailing among sanitary authorities in Massachusetts regarding the value of the measure of placarding the houses, it seemed well to the Board to give the method a trial in Cambridge, with regard to two eminently communicable diseases, diphtheria and scarlet-fever; and with this end in view it was decided to place on every house wherein such diseases existed a placard setting forth this fact. It was also decided that, upon notification from the attending physician that the danger from contagion was over, the placard should be removed, and the premises fumigated by an agent of the Board for those who were unable to do this themselves, or to bear the expense of the proceeding. Those who could pay for the material used would be expected to do so. It seems almost unnecessary to add that by the words "when the danger from contagion is over" is meant that the time has come when the patient has ceased

to reproduce the specific contagium of the disease, so far as a competent authority is able to form an opinion on the subject. Any measures of so-called disinfection of the premises while the contagium is still being reproduced and disseminated must be of very little value. In the next place, some plain directions may be sent to each house wherein a case of one of the diseases under consideration exists, setting forth the means that seem to be capable of limiting in some degree the diffusion of the contagium. Sprinkling solutions of carbolic acid round the room, or hanging sheets soaked with that or any other substance before the door, being such puerile proceedings, the wonder is that they could ever have been seriously proposed. The most scrupulous cleanliness of the patient and his surroundings, and a plentiful supply of pure air, are, however, measures regarding the value of which there can be little difference of opinion; and, if these points are carefully attended to, any after-purification of the premises will be a matter much easier and surer of accomplishment. The explanation of the advantages of the directions given and the general supervision over their carrying out should be left with the physician having charge of the case.

Canton.

Ninety-seven complaints for nuisances have been filed, and each was at once abated.

Two cases of glanders in horses were reported, and the animals were killed by order of the cattle commissioners.

Chicopee.

All persons engaged in offensive trades are required to procure a license from the Board of Health. In one case, though refusing to grant a license because the processes of manufacture and condition of the premises were unsatisfactory, the Board permitted its continuance, in consequence of representations of improved processes in course of construction. It is expected that the coming season will correct all objections heretofore existing to this industry.

The oil used by the Overman Wheel Company as a source of motive power found its way into the sewers the latter part of the season, in such quantities as to be a source of offence to the greater portion of the village of the Falls. This was manifestly due to want of experience in its use, and faulty methods of construction. Such changes have been made as will, it is expected, remedy this in the future.

Reference is made to the necessity of securing a new source of water supply, in consequence of increasing pollution of the Chicopee River.

Clinton.

The Board has received and investigated fifty-four complaints, all of which were satisfactorily abated under the supervision of the Board, excepting in two cases which we were obliged to bring before the court, after which the nuisances were abated, to the entire satisfaction of all parties.

We have received and investigated four cases of diseases among domestic animals, one being a glandered horse, which was killed after proper investigation; two of the other cases were tuberculosis in cows.

During the past year the long-existing Counterpane Pond nuisance has been abated, and is now a thing of the past; there exists now only the natural stream.

Danvers.

The general condition of the town has compared favorably with preceding years. No serious evils or diseases have resulted from defective drainage, foul odors or absence of proper sanitary precautions. Local and private nuisances have, for the most part, been promptly abated when attention has been called thereto.

Dedham.

It was proposed to begin a course of house-to-house inspection, with the twofold object of ascertaining actual conditions, and suggesting such changes as the Board believe are needed to make the town a pleasanter and more healthful place of abode for its inhabitants. It was not expected that a work of this kind would be completed in a single year, but a beginning was made, and we believe that not a little good has been accomplished. As no special notices were given of time or places to be visited, beyond the general statement that inspection would begin immediately after the 25th of May, we are satisfied that the annual spring "cleaning up" was more promptly attended to than in previous years. The placing of our "rules and regulations" in the houses of the entire town must have had an influence for good.

Easthampton.

At the commencement of this year diphtheria was still appearing occasionally, and continued to appear during the spring and summer until August 7, at which time the last report was received. Increased vigilance in quarantine regulations, destruction by fire of infected household goods where any probability of danger existed, have been pursued until the epidemic has at last disappeared.

Fall River.

With the beginning of the year an ordinance went into effect providing for the appointment of an official known as the inspector of plumbing. In accordance with this order, on the first day of March the inspector entered upon the duties of that office, which he has performed with zeal and ability. In addition to rigidly inspecting the plumbing and drainage systems of all new buildings which have been erected since his appointment, he has supervised all repairs made in old buildings, which guarantee them against becoming a source whereby diseases may be introduced and propagated.

Not taking measles into consideration, of which disease it is not considered necessary to keep a record, the whole number of contagious diseases reported to the Board for the year was 329, against 353 cases the previous year and 488 in the year 1889.

During the year 1,006 persons have been successfully vaccinated under the direction of the city physician.

Four horses affected with glanders were killed and disposed of during the year, in accordance with the directions of the State Cattle Commissioners.

Complaints investigated, 965.

The disease which most largely contributed to the mortality in the class of zymotic or preventable diseases was cholera infantum, which caused 257 deaths, or 14.17 per cent. of all deaths, as against 185 deaths, or 11.17 per cent. of all deaths, in 1890.

Fitchburg.

The work of the Board was greatly increased the past year on account of the epidemic of measles that prevailed in the city the first few months of the year; and, later, the enforcing of the law discontinuing the use of privy vaults on the line of sewers, when such vaults were considered nuisances by the Board.

We are satisfied that the cases of typhoid fever have not all been reported, from the fact that there were only thirteen cases reported, while there were five deaths, which shows a much more fatal type of the disease than probably exists.

Complaints received and investigated,	191
Plumbing jobs inspected by agent,	186
Houses fumigated and instructions given,	245
Cesspools and privy vaults cleaned by permission,	360

Four prosecutions were made during the year, one each for the following offences: burying contents of privy vaults on premises;

opening privy vaults without license; keeping fowls without license; doing plumbing work without license.

Disposal of sewage is one of the most important subjects that is interesting the public, and the needs of this city should be attended to before rather than after an epidemic disease threatens the health and lives of our citizens. The experiment of purifying the sewage before it enters the river has been undertaken by the United States Sewage Filtering and Fertilizing Company, at the outlet of our largest sewer.

Gardner.

The main trunk lines of the proposed system of sewers have been laid in the Centre and West villages, and are in operation. Everything is working in a favorable manner, and the results are as satisfactory as was anticipated. The Derby Pond, also, which has been a menacing source of danger for some time, from the large accumulation of filth that had collected therein and which was steadily increasing, is now entirely relieved, as every one bordering on the pond has either made entrance into the sewers or satisfactory private sanitary arrangements. As every improvement carries with it some element of danger, the Board would particularly request householders to see that, where entrance is made into the sewers, the plumbing is done in a careful and thorough manner.

In conclusion, we would state that the sanitary condition of the town has been steadily improving during the past few years, and, as the system of sewers is developed and entrance made therein, a greater degree of immunity from contagious diseases will result.

Franklin.

Since our last report, in which your attention was called to the large number of children not vaccinated, we are pleased to be able to state that the school committee voted that no scholar, except for adequate cause, should be allowed to attend the public schools unless properly vaccinated. The result is that all scholars now in the public schools are protected by it. But we have reason to believe that there are still a large number of children under five years of age yet unvaccinated. For this neglect of the requirements of the law, parents, guardians and the selectmen must be held responsible.

Gloucester.

The large amount of fresh fish dressed on our wharves during the winter of 1890–91 caused large quantities of waste to collect under the wharves. An inspection of them was made, and the occupants of

each wharf where such waste was found were directed to remove these deposits. While it is not the purpose of the Board of Health to hamper the fish trade, there seems to be considerable evidence that collections of this kind may originate sickness. Collections of fish waste which are covered by water at low tide do not seem to be offensive.

Two cases of glanders were reported to the Board, and both horses were afterward killed and the stable disinfected.

During the past year warning cards have been placed on houses containing cases of scarlet-fever and diphtheria. The people have seemed very kindly disposed towards this innovation. Some of the cards were removed without permission from the Board of Health, but we believe through a misunderstanding. The Board of Health reserves the right to order the removal of these cards upon the recommendation of the physician in attendance. At the first of the year, some, through a misunderstanding, failed to become informed of this part of our order. About one hundred and thirty-five or one hundred and forty different houses were placarded during the year.

Great Barrington.

That the five years of the existence of a board of health has established the fact of its usefulness, and that it has become a necessity and a benefit to the people, few will deny; and it is also evident that, with the progress and growth of the villages, the necessity of such a body not only becomes greater, but the responsibility increases, the duties multiply and the prompt performance of them becomes more imperative. And the people also show an increasing disposition to aid the Board in its efforts, and to avail themselves of the help thus offered in carrying out hygienic measures and in suppressing those local causes of disease which are sporadic, and are ever present in our midst; for be it known that local boards are maintained and prove their usefulness not only in securing accurate and valuable statistics, but also in preventing and modifying zymotic diseases, which constitute a large share of the prevailing acute maladies, and which tend to increase and become more virulent as population grows and becomes centralized.

The death rate in the town as well as elsewhere during the year 1891 was rather larger than usual; the epidemic of influenza made its presence sadly felt among us, invading nearly every household.

Typhoid fever of a severe type has invaded several houses in this village during the past fall and early winter, resulting in the loss of life. It is a notable fact that nearly every case occurred outside of the limits of our public water supply.

Greenfield.

It seems to us that some action should be taken by the town to provide for the systematic removal of house refuse and garbage from such houses as have at present no means of disposing of such accumulations.

We would recommend that the town vote to instruct the selectmen and the Board of Health to have charge of the disposition of all refuse, garbage and offal of the town.

Haverhill.

The cause of the increase in the number of deaths is found in the epidemic of influenza and other allied diseases which prevailed during the month of December and the latter part of November. Though there are no data in the possession of the Board by which the actual number of those affected can be determined, there is not much doubt that it was between thirty and forty per cent. of the adult population of the city; and, though but eighteen deaths are directly attributed to this cause, yet the diseases incident to it, such as pneumonia, bronchitis and other allied affections, show a considerable increase over previous years. Many of the deaths which occurred were of persons of advanced age and those who were debilitated by chronic ailments.

The deaths from zymotic diseases were but 15.16 per cent. of the mortality, or 3.02 to each 1,000 of population.

Holyoke.

After about two years' immunity, a case of small-pox appeared in our midst in April. Though occurring in a family of thirteen persons, and in a large eight-tenement building, the speedy removal of the patient and thorough vaccination of all exposed fortunately limited the outbreak to a single case. The patient, a woman of twenty-two years of age, was employed in a paper-mill rag-room, and, though vaccinated in youth, had the disease in a very severe form, but made a good recovery.

Quite a large number of the inhabitants of our city, especially children, we believe are wholly unprotected by vaccination.

Scarlet-fever and diphtheria have prevailed to some extent throughout the year, but with only ordinary fatality. Typhoid fever has appeared to about the same extent as for three or four years past. The State Board of Health has made a close study of the causes possible for the prevalence of this disease here. While no definite results have yet been reported by the Board, the use of canal water

in factories for drinking purposes is believed to have been somewhat a factor. On the suggestion of the State Board, the water was interdicted by our Board by placing labels and notices of warning in all shops and mills.

Measles appeared to a limited extent in the early part of the year, and whooping-cough was almost unknown throughout the year.

Vaccination has been done for all school children who made application, the number during the year having been 385. Certificates of vaccination were furnished to school children and mill operatives to the number of about 1,200. A special appropriation is advised for the purpose of general vaccination.

Hull.

Nearly all the houses in the village are connected with the sewer, and it is hoped that in a short time all will see the great benefits to be derived, and make connections. During the past summer the town extended its system of sewerage by building a sewer at Stony Beach, which will drain the low lands and be of great benefit to residents of that vicinity. The drainage at Bayside during the past season was considerably better than formerly, but still there is a good chance for improvement.

The sanitary condition of the town has been good. During the year no contagious diseases have been reported.

Lancaster.

There have been several cases of suspected tuberculosis among animals reported to and investigated by the Board. Five of these animals were killed by their owners, and were found to be tuberculous. Four cases of suspected glanders and one of farcy have been investigated. One case of farcy and one of glanders have, by order of the State Board of Cattle Commissioners, been destroyed, and the premises where the animals had been kept thoroughly disinfected.

Lexington.

A number of complaints of various nuisances have been made. These have received prompt personal attention, and in all cases the decisions and requirements of the Board have been met in a proper spirit, and our instructions have been carried out in a satisfactory manner.

It must be remembered, however, that some of these nuisances will occur again and again, until a drainage system is established sufficient for the needs of the town.

During the year there have been reported one case of diphtheria, three of typhoid fever and eleven of scarlet-fever. In these last mentioned the disease for the most part assumed a mild type. The reports cover a period of three months, six of the cases occurring in one family.

Lowell.

Health laws should not be made for oppression; but, if errors are to be made in them, they should be made on the side of the necessities of the many, rather than in yielding to the assumed rights of the few. So long as contagious diseases can be prevented, and so long as the health and comfort of a community are disturbed by nuisances, the need remains for greater work and further progress.

Especially the older tenement-houses in Lowell are in a very bad condition. They are considered as an investment by their owners, and they are expected to yield as large an income as possible, and the health of the tenant is rarely taken into consideration.

During the year 1891, 18,550 loads of ashes were removed from houses to the different dumping grounds that we have in use. The Board of Health has repeatedly called the attention of the city council to the condition of the dumps, to the complaints that have been made, and to the desirability of destroying the garbage of the city by cremation.

A bath-house was launched for business July 1, and up to September 24, when it was closed, 21,853 baths were taken in its waters.

Lowell is very well furnished with accommodations in case of the breaking out of small-pox, but it is unfortunate that we have not a similar institution, nearer the heart of the city, for the isolation and proper treatment of diphtheria and scarlet-fever. If efficient methods can be applied to the eradication of one contagious disease, why may they not, by vigorous enforcements, be of great advantage in other diseases, classed as preventive, which are always with us? Until we can thoroughly isolate patients, particularly those of the poorer classes, who have had bad hygienic surroundings, we shall some time have to meet a frightful mortality from these diseases. And in connection with a hospital of this description could be built a public disinfecting station, where the furniture, carpets, bedding and wearing apparel from houses in which there may have been contagious diseases may be sent and thoroughly disinfected.

In the opinion of the Board of Health, typhoid fever is more to be dreaded by the population of Lowell than all the other contagious diseases. It is a disease to which every one is exposed, and, so far as we know, immunity from it cannot be purchased by submitting to attack. So far as the study of the Board has gone, they have

reached the conclusion that, so long as the sewage of Manchester, Hooksett, Suncook and Nashua drains into our water supply, we are surrounded by its infection and cannot escape. It flows beside us in the river, in our mains, from the taps in our houses; the germ of disease may not be in this pitcherful or in that, but it will find us some day if we continue to use the water which contains it. About one victim in Lowell is taken daily, and, as the average duration of this fever is about a month, there are always thirty persons in this city whose lives are trembling in the balance. Calculate the loss by sickness, the loss of work, the unprofitable work of nursing, and the actual outlay caused by each visitation of the disease, and it will be seen that every possible help should be given by the physicians, instead of refusing to report cases, so that the health department may do what little they can to prevent its increase. All the information possible is gleaned in each case, and made a matter of record at the office of the Board, and the time will come when it will be useful as a basis for study and analysis.

LYNN.

After a thorough and careful investigation, the Board of Health decided the works of the Lynn Glue Company to be a public nuisance, and on April 13 issued an order to cease and desist from carrying on business. The order was complied with by the company, and their business has been moved to Salem.

Immediate provision will have to be made by the incoming city government for a modern system for the disposal of house offal and night soil. Not only have the householders and residents in the immediate neighborhood of the present dump protested (and justly so) against its maintenance, but the owner of the land has notified the Board that at the expiration of its lease the coming spring it will not be renewed. In what manner the exigency can be best met is a momentous question, and requires deliberate consideration. For the disposal of garbage the Board is favorably impressed with the suggestion of the Boston Board, as embodied in their report for the year 1891.

MARLBOROUGH.

The Board early made regulations in regard to the removal of house dirt and rubbish by a scavenger. Though work done in the line of preventing epidemics of disease is not easily demonstrable, we are convinced, from the inspection of the houses and surroundings in the streets covered by the scavenger, that his work did much toward remedying one of the worst nuisances of the city. The mem-

bers of the Board have done what they could, by ordering the brooks cleared from time to time, to change the filthy condition of the drain on French Hill. The condition of this brook or drain, which has been a source of annoyance for years, and about which a petition was sent to the city council last year, will no doubt be improved after the sewer connections are made.

The city has been comparatively free from severe contagious disease this year. The number of cases of scarlet-fever in the tabulated report of contagious diseases would indicate more danger than has actually been present, for the cases have been so mild that not a single death from this disease was reported during the year.

The attention of the Board was called to only one case of tuberculosis in beef slaughtered in this city. The cattle commissioners received due notice of this case, and pronounced the beef unfit for use. It was disposed of by our orders.

Marshfield.

On the day of the first meeting of the Board, April 22, a thorough inspection in the shore villages was made; and, on different dates, this precaution was repeated. At this inspection the neglected condition of insufficient sink drains or sewers, cesspools and out-houses, — there being a frequent lack of vaults and other common conveniences, — made it plainly manifest that, unless there was a complete renovation and improvement, escape from zymotic diseases would be well-nigh miraculous.

It became necessary to declare as unfit for use one of the oldest, if not the oldest, of the wells. As illustrative of too common carelessness, this well is further described. Increasing sickness in a family causes the attending physician to surmise that it was caused by the water they used, which was from the well under consideration. It was found to be very filthy; but eighteen inches deep in the well, the well but six feet five inches deep; twenty-seven feet northerly there was a putrid dung heap, garnished by decaying garbage; thirty feet southerly, at the summit of ground rising two feet in ten, was another manure heap. And between forty and fifty people were using the water of this well daily.

The subject of the removal of garbage is perplexing, and it has been difficult to deal with. In view of existing indications of increase in population, from May 1 to October, more particularly, it may suggest itself to you whether artificial means, by burning or otherwise, may not be the most feasible method to dispose of it.

There was one case of glanders. The horse was quarantined, and the cattle commissioners notified.

Maynard.

As a Board of Health we have tried: —

1. To prevent the introduction into or origin in the town of all contagious and infectious diseases.

2. When such diseases occur, to prevent their spread in the town or among neighbors, and to render the germs of disease harmless.

3. To insist, as far as possible, that householders and landlords should feel and act on their own responsibility to keep their surroundings and those of their tenants and dependents in a clean and wholesome condition, so that they may be in better general condition, and, should disease be contracted, able to better resist its destructive influence.

A careful inspection of tenement-houses, vaults, cesspools, drains, pig-pens and barn cellars has been made in the more thickly settled portions of the town.

Houses in which contagious diseases have occurred were thoroughly fumigated and vaults disinfected.

Red flags were put on houses where scarlet-fever and diphtheria existed, and families instructed in necessary precautions; and we believe that these diseases have been much controlled in their spread by the precautions taken.

Care has been taken to keep children with whooping-cough out of the schools.

The unusual exemption from cases of contagious diseases this winter has made a saving of expense which it would not have been safe to count on in advance.

Medford.

We earnestly recommend that the town, through its committee, push energetically the work of constructing our local sewerage system, so that we may be able, at the earliest possible moment, to avail ourselves of the benefits of the Metropolitan system of sewerage.

The custom which prevails more or less generally of allowing the swill and garbage which is collected throughout towns to be used as food for pigs, encourages the business of pork raising. The only known satisfactory manner of disposing of swill, filth and garbage is to burn them, and we heartily endorse the recommendation of previous boards of health in this town, that a crematory be provided for this purpose.

Melrose.

Much of the complaint from that intolerable nuisance, a piggery, has been stopped since the town has undertaken to collect the swill

by contract, and the collection by private individuals has been discontinued.

On the 24th of September the Board of Health, being informed that malignant diphtheria existed in the town of Saugus, investigated the report at once, and found the disease in the family of a milkman; that one of his children had died of diphtheria; and also found that he had supplied milk to two of our local milkmen, one of whom was still obtaining a portion of his supply there. Further investigation showed that the one who first obtained his supply there, when he saw diphtheria appearing on his route, stopped taking this milk, but did not notify the Board of Health. It was upon the route of this same man that diphtheria appeared when it was epidemic in Melrose in 1886, and from his experience he readily associated cause and effect, and sought milk elsewhere. It is to be regretted that another should have taken this same milk, — a thing that would have been prevented had the Board known of the above facts earlier. This milk supply was stopped immediately, and energetic measures taken to thoroughly disinfect all vessels that had been used in the conveyance of this milk. No can was left at any house containing a case of diphtheria, isolation was enforced, and disinfection was carried out under the direction of the Board of Health. The schools at the Melrose Highlands were closed, and every precaution that suggested itself taken to prevent further spread of the disease. By these means the Board of Health know that the spread of the disease was stopped, the only cases appearing afterwards being in the families where the disease had existed, and in those who had been exposed by contact with the patient. Every case of diphtheria was directly traced to this milk.

So far as known, physicians have faithfully reported their cases of contagious diseases, and many householders, as required by the law of the State, have notified the Board of cases in their own families. As to the number of cases of measles, the explanation is found in the popular idea of the harmlessness of the disease, and in the consequent neglect of isolation. This is wrong, for no one from one case can judge of the severity of subsequent cases; and, although the mortality from measles is small, yet complications may follow, that, if they do not result fatally, injure the patient perhaps for life.

Houses containing cases of scarlet-fever and diphtheria have been placarded as heretofore. When the card is posted, inquiry is made as to the probable source of the disease, the number of families in the house, the number of children, and what schools they attend. The teacher or teachers are then informed, upon a printed slip, of the name and residence of the patient, and notified that such children be excluded from school until such time as the Board of Health or attending physician certifies that they may be safely readmitted.

Milford.

During the months of January and February, 1891, the town suffered from an epidemic of scarlet-fever. Fortunately the epidemic was of a mild form, and was attended by a very low death rate.

In December, 1891, and January and February, 1892, what promised to become a serious epidemic of diphtheria occurred, — ten or twelve cases within a few days in several parts of the town. But the Board of Health are very glad to be able to say that it has been promptly checked. Several cases of scarlet-fever have also been reported, and have been quarantined by the Board, and in no case has the infection spread from the original cases.

Millbury.

Four cases of glanders have been reported to the Board, and by us reported to the State Cattle Commissioners, and by them condemned to be killed.

But few complaints of nuisances have been made to the Board during the year. We have noticed many places about the town where greater care is needed to prevent the flow into the highway of household wastes, and hope to remedy the evils, but have not thought it wise to exercise authority too arbitrarily.

Nahant.

The notification of the Board of Health of all cases of measles and whooping-cough, in addition to those prescribed by law, and occurring in children, is very important. The exclusion from the schools, by the school committee or some person authorized by them, of all children presenting themselves who, in the opinion of the committee or persons appointed by them, are suffering with sore throat, or who have recently or are but imperfectly recovered from scarlet-fever, diphtheria, whooping-cough or measles, or who come from a house in which these diseases prevail, unless such child has a certificate from the Board of Health or a physician, is a very important measure for consideration. The town has been blessed with a year of health.

Natick.

We have received many complaints of alleged nuisances, have investigated all of them, and in most cases have found that they were well grounded in fact. The aggregate number of visits we have made is large, and in the discharge of our duties we have been called into all parts of the town.

The only work of any magnitude undertaken has been the cleaning

out of the south arm of Pegan Brook as far as Union Street, in accordance with the vote of the town.

The necessity of a purer water supply is more than ever evident, as our Dug Pond water has been very disagreeable to use for domestic purposes, if not injurious to health. Quite a large number of citizens are solving the question by buying their drinking water of those who supply "pure spring water," thus paying a water tax twice or thrice over. This ought not to be so, as water supplied to a town ought to be of such a quality that the poorest citizen may have pure water as well as those that can afford to buy spring water.

Needham.

Some of the most difficult cases to adjust have been the keeping of swine. It is not easy to draw the line definitely between a merely unaccustomed agricultural atmosphere and one that is detrimental to health. Owners of swine and other animals should not forget that neighbors and the public have rights as well as themselves.

No matter what system of ventilation is used, it is of vital importance that the air supply should be derived from a pure source, and that for the effective working of any scheme of artificial ventilation the following are essential: —

1. An inlet for fresh air.
2. An outlet for vitiated air.
3. Proper means of promoting the motion of the air current in the right direction.

New Bedford.

It was ordered by the Board of Health that all vessels arriving from foreign ports, between the first of May and the first day of November, be directed to go into quarantine until visited by the quarantine physician. All pilots were required to observe and follow this order.

The following regulations were made by the Board relative to plumbing and house drainage (Dec. 16, 1891): —

"Section 1. Filing plans and specifications. No person shall proceed to construct, add to or alter any portion of the drainage system of said buildings (except to repair leaks) until they have filed at the office of the Board of Health, upon blanks in such form as the Board of Health shall order, a notice of the work to be performed.

"No person shall commence work on such drainage or plumbing until the plans are approved by the Board of Health. Plans and specifications will be approved or rejected within five days of the time of filing.

"After a plan has once been approved, no alterations of the same will be allowed except on a written application of the owner.

"Whoever shall violate any provision of these rules shall be liable to a fine not exceeding one hundred dollars, and a like penalty for every day after the first that an offence shall be committed."

Inspections made, 1,921.

From May 1 to Nov. 1, 1891, thirteen vessels arriving from foreign ports were boarded. No vessels were detained in quarantine, as they brought no cases of contagious diseases.

Newburyport.

Besides the work of investigating complaints, the agent puts up on houses where diphtheria appears a white card, and where scarlet-fever appears a red card. After these houses have been properly disinfected he removes the cards. In many cases he has been obliged to do errands for the household in which diphtheria appeared; and in one case the Board has paid to provide for the family for a short time.

Cases of contagious diseases reported in 1890, 177; cases of contagious diseases reported in 1891, 122, — showing a decrease of 55 cases, which, in the opinion of the Board, is owing to the sewer system, which is beginning to show its good effects within the bounds where it has been constructed, as only four cases of diphtheria out of the seventy reported occurred where the sewer has been constructed, and these in houses not connected with the sewers. We would recommend to the city council the pushing forward of the sewer as fast as possible, in the interest of good health and the sanitary condition of the city.

The physicians the past year have performed their duties in a faithful manner, reporting all cases of contagious diseases promptly. We hope that at no distant day a ward for patients suffering from contagious diseases, especially children suffering from diphtheria (where there is a large family of them), may be established at the Anna Jaques Hospital.

North Andover.

Up to date seventeen houses have been fumigated. In four of the above houses secondary cases of diphtheria occurred, but in no house was there a return of the disease after the sink was trapped and the privy vault cleaned. The above fact proves that, while fumigating is beneficial, yet, as long as the source or cause of the disease remains (whether it is the condition of the sink drain, vault or other cause), fumigating alone is useless. For three successive years diphtheria

has been prevalent in this town, and, unless strict sanitary measures are taken at once, it is more than likely that in the spring there will be a return of that dreaded disease.

Norwood.

Owing to the large number of cases of scarlet-fever and diphtheria having been reported to us, we ordered the schools closed for two weeks, and, as a Board of Health, have made rules and regulations for the guidance of the citizens of the town, which we shall ask to have adopted at the annual meeting.

Palmer.

In most parts of the village, the ground being level, the surface drainage is very poor, and the filth that has accumulated in the numerous cesspools has so permeated the ground that the action of the sun and frost in an open winter like the past allows the dangerous elements to escape, to become a menace to the public health. This ought not to be allowed to continue. Sewers should be built, and the abutters be obliged to enter them.

During the scarlet-fever epidemic the attack was unusually severe. In all cases the school committee were at once notified, the houses placarded, and rules in regard to quarantine and disinfection, as strong as in the opinion of the Board the courts would sustain, were published, and a copy left at every house where the disease existed, and an officer appointed to see that they were enforced. But in a town like ours, without a salaried police, it is nearly impossible to maintain strict quarantine regulations without the hearty co-operation of the people.

Plymouth.

Very few cases of contagious diseases have been reported to the Board this year, which the Board think is largely due to the fact that early in the season an agent was sent throughout the thickly settled portions of the town, all places which were in a bad state of sewerage were reported to the Board, and they were at once attended to, and made as clean and healthy as possible.

Provincetown.

There has been a large number of cases of typhoid fever and scarlet-fever, several of which have proved fatal. We think there is need of reflection and due investigation to ascertain the cause of so much illness from typhoid fever, and to try and prevent the propagation and diffusion of it in the future.

Quincy.

The inspector furnishes the following table of nuisances and abatements: —

Number of inspections made,	3,542
Nuisances discovered,	348
Nuisances abated,	342

In most cases a simple notification to the offending party has been sufficient to cause the removal of the nuisance, and in no case have we been obliged to resort to legal measures. On the contrary, we note with satisfaction the growing desire on the part of the public to co-operate with the Board in securing the sanitary welfare of the city.

The most important work performed during the year has been, unquestionably, that which was done upon the various water ways of the city. Under the supervision of the commissioner of public works, whom the Board appointed as its special agent, the Town Brook, Sachems Brook and Furnace Brook have been thoroughly cleaned out, widened and deepened. The value of these operations must be apparent to all.

Unfortunately, the table of contagious diseases reported is not of sufficient accuracy to give more than a general idea of the prevalence of these diseases and the percentage of deaths, this inaccuracy being due to the negligence on the part of our physicians in reporting cases coming under their care.

Reading.

In all cases reported to the Board warning cards have been placed on the houses, in cases of diphtheria or typhoid fever the sanitary condition of the premises has been investigated, and in all cases have the premises been fumigated.

A large number of complaints of nuisances were received. Fourteen received our particular attention, and in most cases were promptly abated by owners after receiving notice from the Board.

Rockland.

With the exception of the recent epidemic of influenza, the general health of the town for the past year has been exceptionally good, in fact, the best, in the matter of contagious and infectious diseases, for many years, there having been reported to the Board only ten cases of a contagious or infectious nature.

In regard to nuisances, there has been an unusually large number reported to and investigated by the Board. Careful attention has been given to all properly reported cases, and in the matter of abatement of the same the efforts of the Board have been readily and cheerfully met, and their advice followed by the property holder upon whose premises such nuisances have occurred.

Revere.

Innumerable places of a menacing character have been greatly improved, and very many instances completely remedied. Absolute safety from cesspool filth will never be attained in Revere until cesspools are abolished, the character of the subsoil and immense strata of clay underlying nearly the entire town serving to prevent absorption in any practical degree. It is absolutely necessary, therefore, that the waste material from dwellings and places of human habitation be removed by a system of sewerage.

So much trouble and annoyance has been caused in past years in regard to the method of cleaning vaults and cesspools within the town, that the Board determined to establish a system for doing all such work. Accordingly a license was granted by the Board, the manner of doing such work and the disposal of all offal so collected to be at all times under the order and approval of the Board, the odorless process with tank wagon to be used in cesspool work, and the rubber-top barrels to be used in vault work. Specifications were attached to the contract in regard to detail in the work, at all times to be under the direction of the Board of Health, and a bond was given in the sum of one thousand dollars for the faithful performance of the work.

The number of houses disinfected and fumigated by the Board is ninety.

The number of disinfections paid for by the Board was: dwelling-houses, forty-seven; school-houses, three; library books, two lots.

Salem.

Changes in methods of collecting and disposing of the garbage will undoubtedly be necessary in the near future, and, as preliminary to a new system, visits were made to a new crematory furnace at Gravesend, N. Y.

Two hundred and forty-six recorded complaints have been attended to. Eighty dead animals have been taken care of.

By vote of the city council, a sanitary examination of the school-houses was made under the direction of this Board. More attention should be given to the ventilation of the dressing rooms of our school-

houses. This Board would recommend the investigation of a system which, we understand, has been recently introduced in a new schoolhouse at Lexington, Mass., the principle of which is to hang the clothing on wire screens, thus allowing free circulation of air.

Saugus.

Many complaints being made to the Board regarding the keeping of swine in the town, the Board on investigation found that quite a number of the citizens and others were bringing swill from the surrounding cities and towns, carting it through our streets, creating thereby a dangerous and obnoxious nuisance. So serious had this become that the Board found it necessary to take very stringent measures, and we are pleased to report that those measures proved effective, and the town, now free from this nuisance, we believe can be kept so by the enforcement of our by-laws.

Sharon.

The high death rate may in part be attributed to the prevailing epidemic of influenza, which has proved especially fatal among consumptives, weak and aged persons; an unusually large proportion of the latter succumbed during the year. The fact that the town is a resort for invalids, especially consumptives, and that it also contains many infants (often in feeble health) sent here from public institutions, is the cause of a considerable increase over our normal death rate. The small fatality from zymotic diseases may be noted.

One case of glanders in a horse was reported.

Somerville.

Number of nuisances complained of, ...	687
Number of nuisances abated, ...	571

Several cases of glanders have occurred during the year.

A thorough examination of all parts of the works, and a study of the different methods of destroying the noxious odors at the slaughterhouses of John P. Squire & Co. and the North Packing and Provision Company, have been made by us in connection with Professor Drown. Professor Drown concludes his very careful inquiry as follows: "It is impossible to have large slaughtering houses in the heart of a city without creating more or less of a nuisance; it is inherent in the operations which are conducted there. I think, however, that, with care in planning the details of the works and with vigilance in maintaining cleanliness, the radius within which this nuisance will make itself felt may be very much restricted."

SOUTHBRIDGE.

The Health Board, in submitting its annual report, is pleased to note, first of all, the entire absence during the year of contagious diseases, not a single case being officially reported. A general inspection of the town was made early in the season by the full Board.

The matter of proper sewerage for the town is of vital importance to every householder, few realizing the danger in the present method of disposing of our sewage. However exacting the health officers or careful the landlord and tenant, this primitive method of drainage is a prolific source of disease, and a disgrace to the town.

SPRINGFIELD.

The death rate for the year, per 1,000 of living population, is 18.66, against 19.42 for 1890.

Comparing the record with that of 1890, we find that there is a smaller number of deaths from diphtheria, tuberculosis and acute diseases of the lungs, a greater number from scarlet-fever, while the other acute diseases show little difference.

Diphtheria has become gradually less frequent since 1889. In that year there were 86 deaths from diphtheria and croup; in 1890 40, and in 1891 32. There is also a falling off in the number of cases reported, the record for the three years being, 213, 118, 67.

Scarlet-fever, on the contrary, is increasing, the reported cases and deaths for three years being: 1889, 60, 0; 1890, 128, 8; 1891, 223, 13. The disease is found in all parts of the city.

SWAMPSCOTT.

We have had a number of signs put up along the beaches, requesting the citizens not to deposit rubbish thereon, and with a few exceptions they have complied with our request. Some of the citizens have made the suggestion that the town provide some means for the collecting of ashes and other rubbish that may collect on their premises; we think the suggestion a good one, and recommend that the citizens take some action at our next annual town meeting.

We have had but four cases of contagious diseases reported this last year.

TAUNTON.

The custom many of our milkmen have of collecting a tub of swill as they go over their milk routes may justly be criticised; it not only befouls the milk carts and cans, but it lays them open to the suspicion of feeding their cows on swill.

Two petitions have been received under the wet, rotten and spongy lands law; and, under the process of the law, the Board has abated

the nuisances complained of. In one case a suit has been commenced against the city for damages done by the Board in draining said lands. The Board feels, however, that it was justified in the action taken, and would adopt a like course in any similar case. One swamp has been drained by the owners upon an order from the Board under the common-nuisance law.

The manner of cleaning the catch-basins is totally wrong, for the following reasons: it is an offence to both eyes and nose, and it is a source of danger to the public, because the material in these basins is a very good soil for the germs of disease to multiply in; and there can be no doubt that, when this material is thrown on the street and allowed to dry, a large amount of dust laden with the germs of tuberculosis (consumption) and possibly other diseases, as diphtheria and typhoid fever, is blown into the air. These germs, when inhaled by the unsuspecting citizen, may be the means of starting a fatal illness. Even when the material is dipped directly into carts, a part of the liquid portions remain on the streets to dry, and so become a probable source of infection. The Board would recommend that the work be done by the odorless excavators, at least in the more thickly settled parts of the city.

About the middle of the year the Board adopted the practice of doing the fumigating by burning sulphur, without expense to the householder. This has been found far easier and more satisfactory than obliging the householder to do it himself.

During the year the Board sent a communication to the city government, setting forth the necessity of a hospital for contagious diseases.

Glanders has been alarmingly prevalent, and owners of valuable horses are advised not to water them at the public fountains.

Waltham.

If we include influenza, no infectious disease has prevailed in our city proper to such an extent as to be considered epidemic. Scarlet-fever in mild form affected about a dozen children living in the upper part of Felton Street and its neighborhood during September and October. A single case, unrecognized and unreported by the physician in charge, was the cause of this outbreak. School quarantine was immediately enforced, but efficient home quarantine was impossible, and single cases have continued to appear over a widening area and in slightly increasing numbers since that time.

The Massachusetts School for Feeble-minded, situated in the north-eastern part of the city, near Belmont, and constituting an almost isolated and independent community of about four hundred

persons, has been visited by a severe epidemic of typhoid fever this autumn. The cases have numbered twenty-five, the deaths two.

The presence of a large number of Italian laborers among us all the season gave occasion for some alarm; but, although their mode of living was far from cleanly, not a single case of infectious disease occurred among them.

This Board strongly recommends the erection, in the immediate neighborhood of our new hospital, of wards suitable for the care of all infectious diseases.

Another very effectual means of combating these infectious diseases is a disinfecting station or furnace, where large articles, such as bedding, furniture, etc., could be disinfected by heat.

We have lately taken some steps toward a more absolute school quarantine. The statute, literally taken, gives boards of health no control over the attendance of infected children at private schools, and, as the parochial schools are really such, this defect is a very serious one. Obviously all schools should be subject to the same sanitary regulations, and boards would probably be sustained in applying the provisions of the present law to them all; but steps have been taken to have its language changed so as to avoid a possible difficulty.

The question of ice supply is yearly assuming more importance. Not only have the quality and quantity of the ice a precarious dependence on the weather, so that at times the cost places it almost beyond the reach of the poor, but it is quite certain that none of the waters from which ice is cut in this city are, on sanitary grounds, suitable for that purpose. The ice is little better than the water, and surely no one would think of drawing a public water supply from the streams which now furnish us ice.

Ware.

On account of the existence of typhoid fever, and for other causes, it has been necessary for the Board to condemn many of the wells in town, and order the town water carried into the houses. Analyses of samples of water taken from several wells at different parts of the town were made. In two of the samples, besides a considerable quantity of organic matter, the analyst found a sufficient amount of lead to produce lead poisoning.

Watertown.

The offensive odors from the Charles River this year have been the subject of a good deal of complaint. The odors have been more like a large open stagnant sewer than anything else, and at times it

seemed to the people in the centre of the town almost unbearable. This Board has done what it could, and also called the attention of the Newton Board of Health to the condition of the river in the city of Newton. The State Board of Health has also been called upon. There is a good deal of vegetable matter in the channel of the stream, which during the warm weather is subject to decay, and emits odors which are very offensive.

WESTFIELD.

The town has suffered more or less from "la grippe," scarlet-fever, typhoid fever and small-pox. That strict observance of rules and regulations would at any time have stamped out the disease we do not claim, but a great many cases would not have appeared if perfect isolation of the patient had been maintained. The small-pox cases were light except one, and did not amount to as much expense as common in such cases.

WINCHESTER.

The general sanitary condition of the town is good, but we are anxiously awaiting the advent of a good system of sewerage. We believe that the time has now come when this question of sewerage should be intelligently studied.

It is our advice that the town employ responsible parties, who shall at stated intervals collect the ashes and take charge of the public dumping places. This method is in operation in some of our neighboring towns, and gives general satisfaction.

WINTHROP.

The offensive odor from the flats was the same this year as the last; the matter was again investigated, and the town made an appropriation for its removal, but, owing to the large amount of offensive matter and the uncertainty of relief, no satisfactory contract could be made for its removal. There is no doubt that the great cause of this odor is from sewage deposits on the flats; from personal examination we find that nearly every house on the harbor side of the town drains on the flats. We think it would be well for us to provide sewers for that part of the town, and correct our own faults before we charge these evils to our neighboring cities and towns.

WORCESTER.

Last April the Board began to placard all houses in which were cases of diphtheria or scarlet-fever. We feel sure that this measure has been of great assistance in checking the spread of contagion; first

by warning the public of the location of the disease, and second by the moral effect on the patient and members of the family, in most cases, causing them to cheerfully submit to the rules and assist in preventing the further spread of disease.

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